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(54) **TWO-STROKE ENGINE, SAND CORE FOR PRODUCING A TWO-STROKE ENGINE, AND METHOD FOR OPERATING A TWO-STROKE ENGINE**

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(73) Assignee: **Andreas Stihl AG & Co. KG**, Waiblingen (DE)

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(51) **Int. Cl.**

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F02B 33/04	(2006.01)
B22C 9/10	(2006.01)
F02B 25/02	(2006.01)
F02B 33/30	(2006.01)
F02F 1/00	(2006.01)
F02F 1/22	(2006.01)
F02B 75/02	(2006.01)

(52) **U.S. Cl.**

CPC . ***F02B 33/04*** (2013.01); ***B22C 9/10*** (2013.01); ***F02B 25/02*** (2013.01); ***F02B 33/30*** (2013.01); ***F02F 1/002*** (2013.01); ***F02F 1/22*** (2013.01); *F02B 2075/025* (2013.01)

(58) **Field of Classification Search**

USPC .... 123/73 PP, 73 R, 65 P, 65 R, 65 A, 65 E, 123/65 S, 65 VA, 50 B, 73 F, 73 FA, 73 AA

See application file for complete search history.

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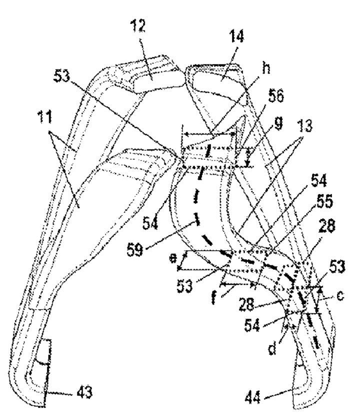
(57) **ABSTRACT**

A two-stroke engine has a cylinder with a combustion chamber and a reciprocating piston for driving a crankshaft. Transfer passages connect the crankcase in at least one position of the piston with the combustion chamber and open by piston-controlled transfer ports into the combustion chamber. An inlet opens into the crankcase and an outlet is provided at the combustion chamber. The engine is dividable into four sectors parallel to a longitudinal cylinder axis. The transfer port of a first transfer passage is arranged in the first sector, the outlet is arranged in the second sector, the transfer port of a second transfer passage is provided in the third sector, and the inlet is arranged in the fourth sector. Within the cylinder the first and second transfer passages, at a spacing from a separation plane between cylinder and crankcase, pass together into one of the second and fourth sectors.

18 Claims, 13 Drawing Sheets



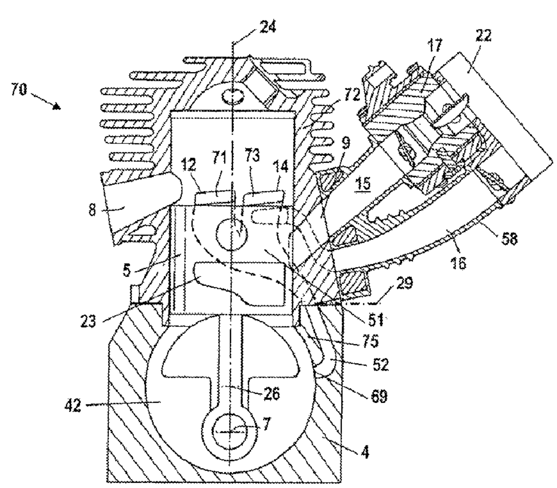


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Fig. 1

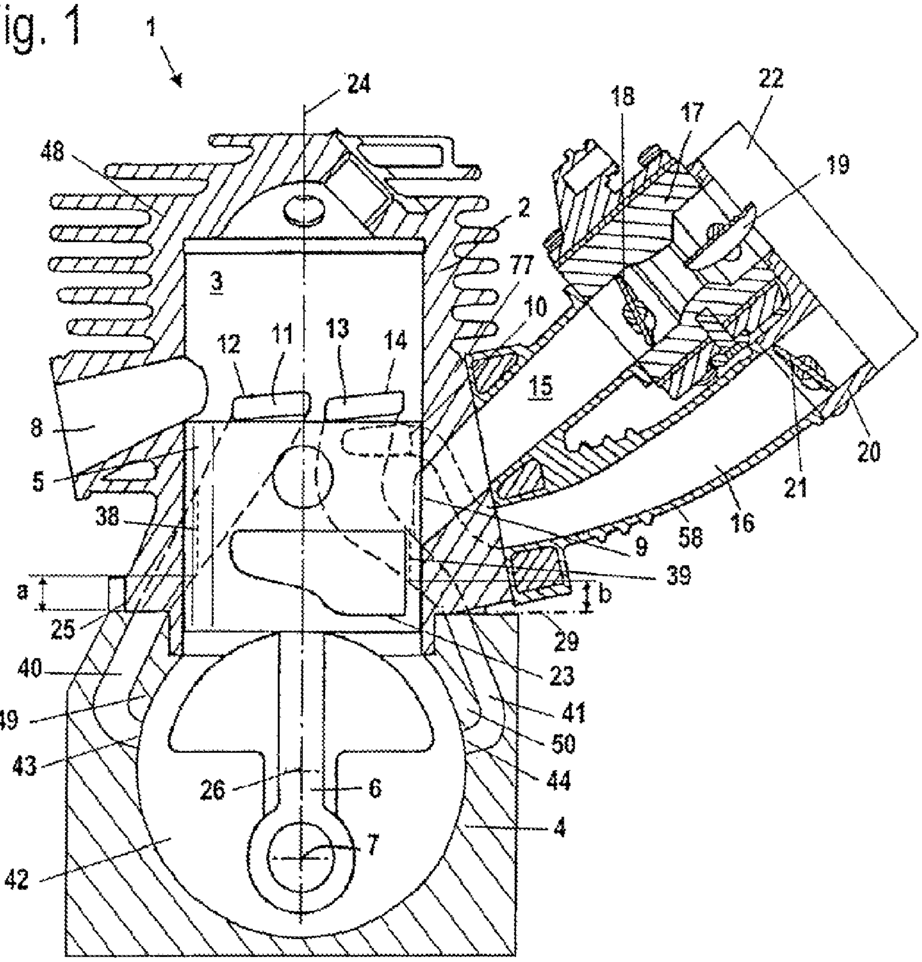

Fig. 2

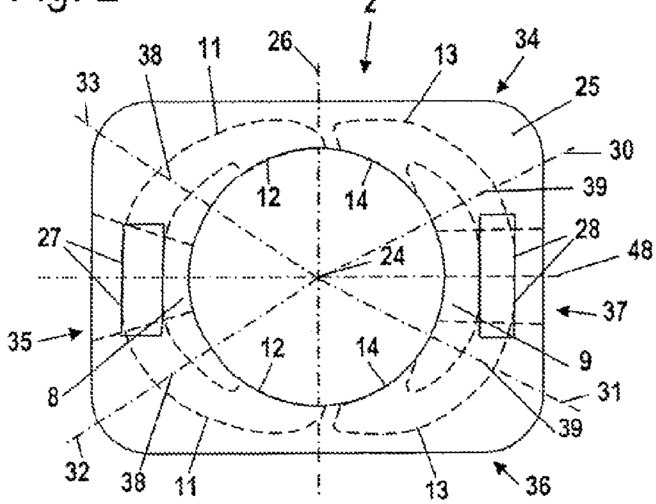

Fig. 3

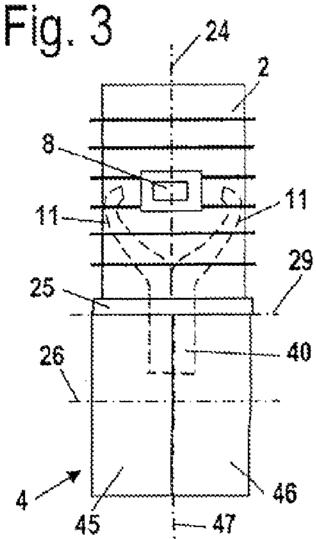

Fig. 4

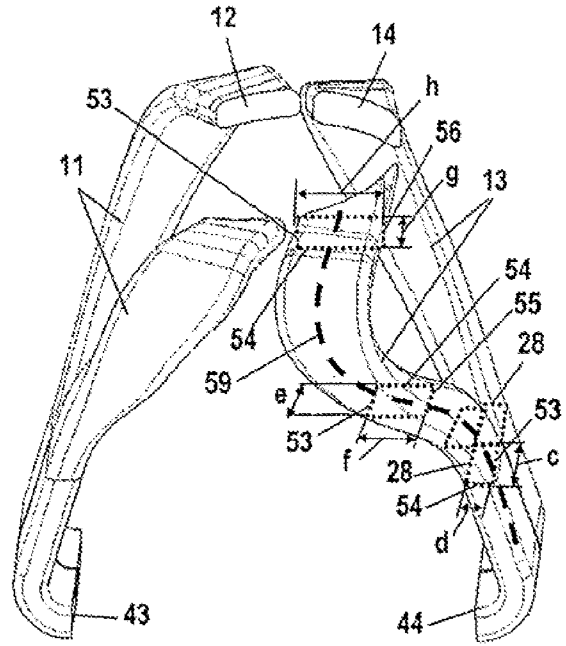
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Fig. 5

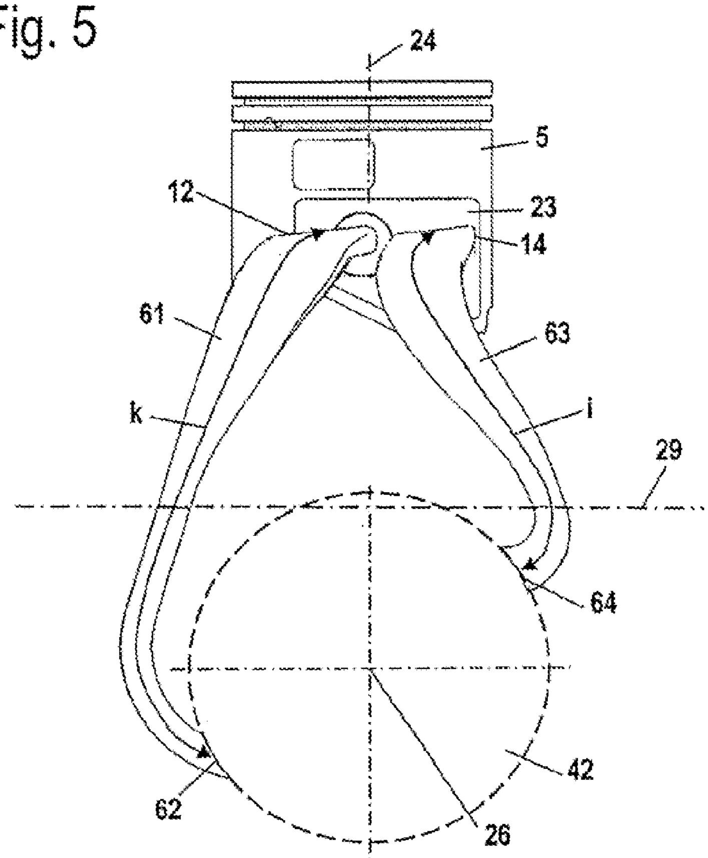
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Fig. 6

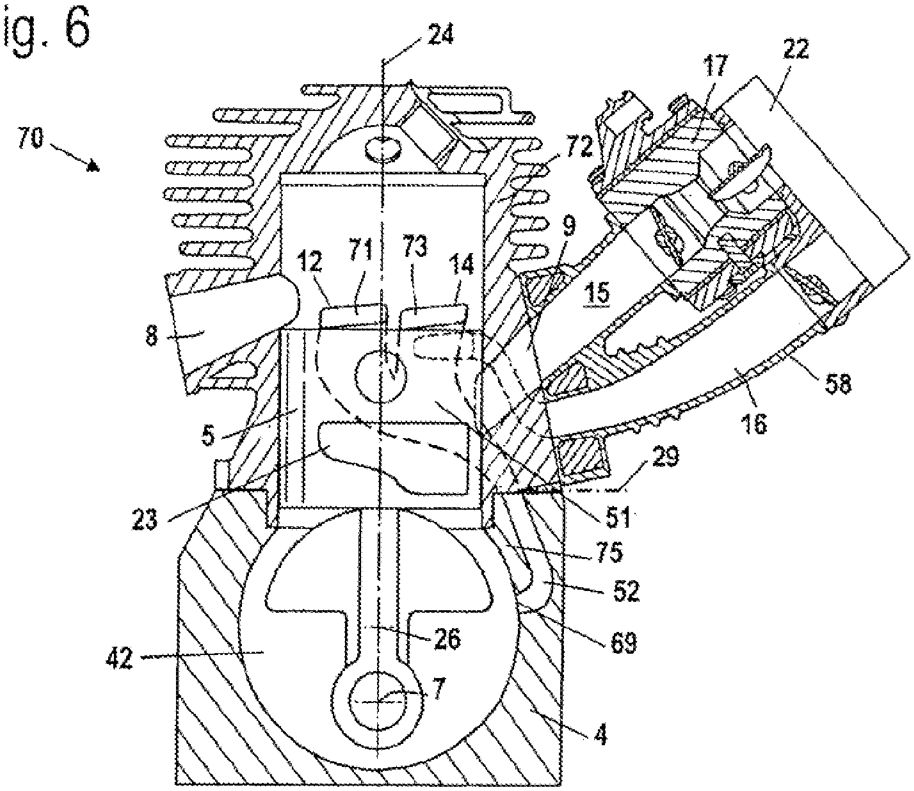
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Fig. 7

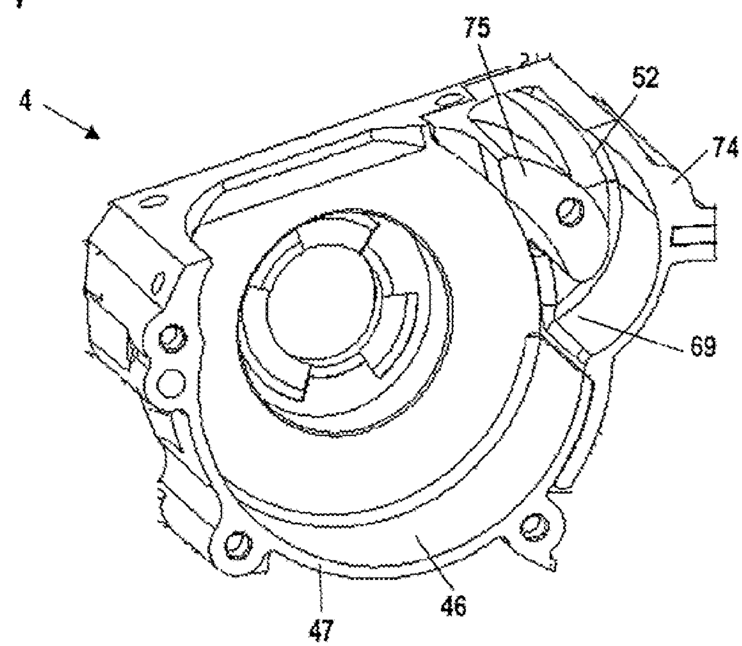
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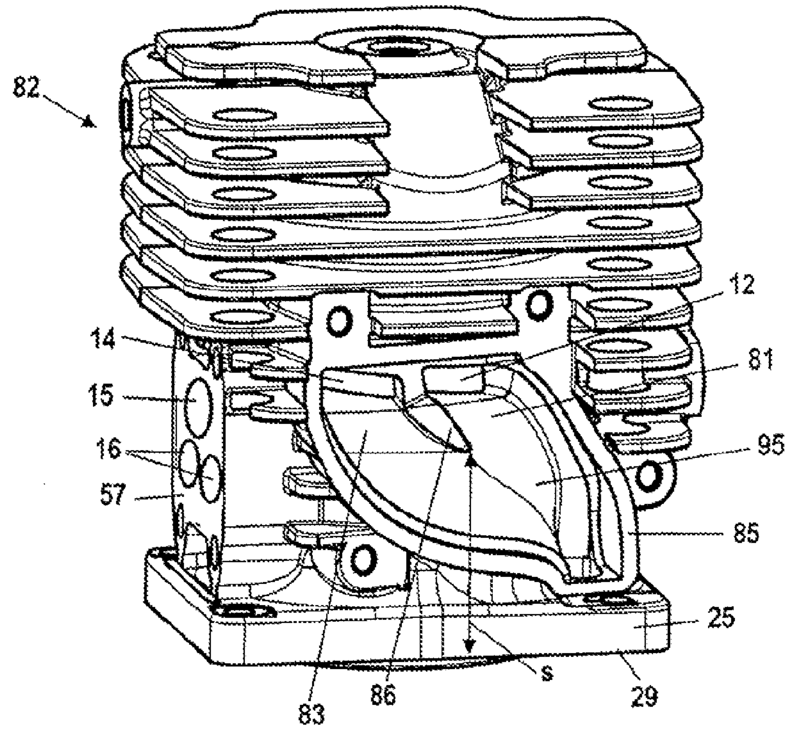
Fig. 8



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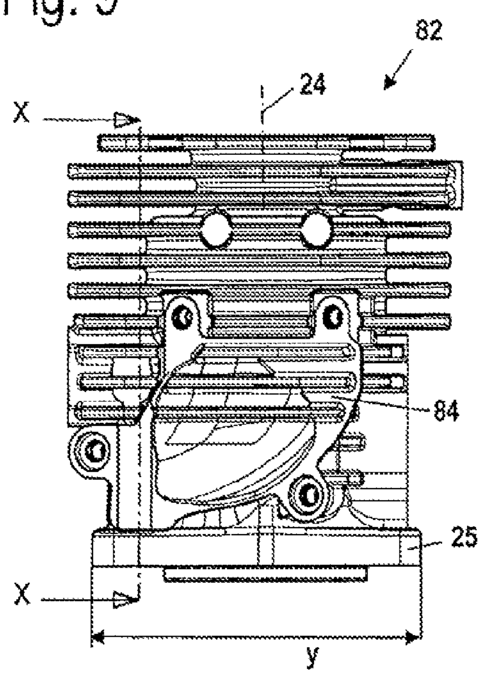

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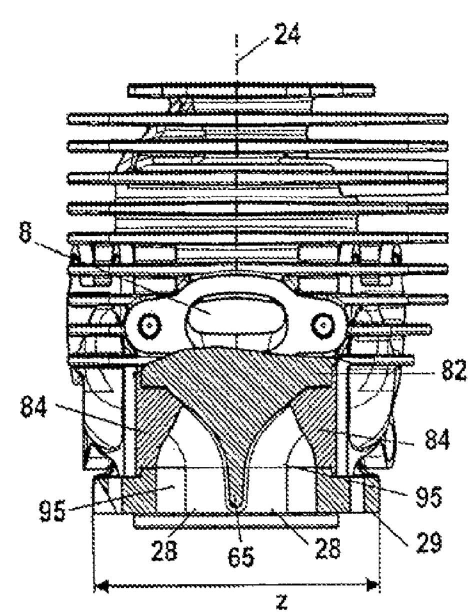

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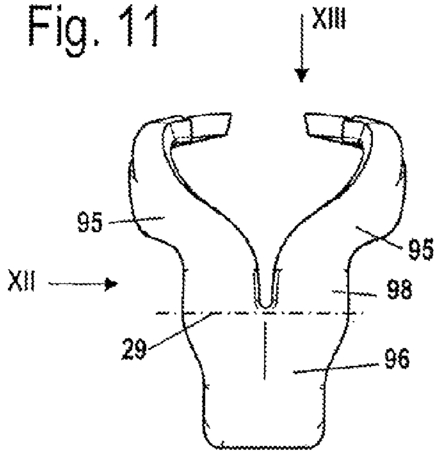

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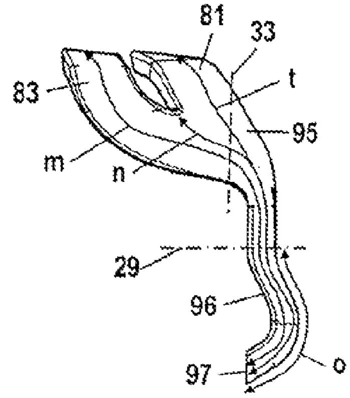

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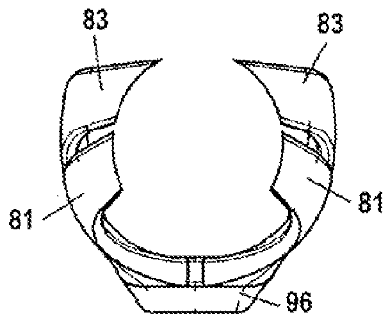

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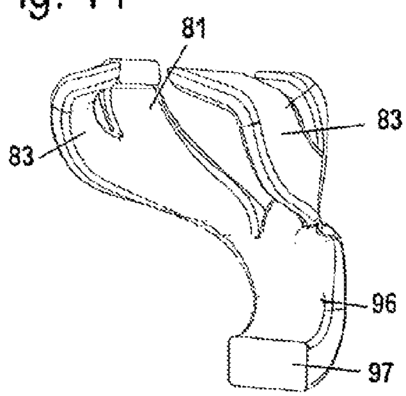

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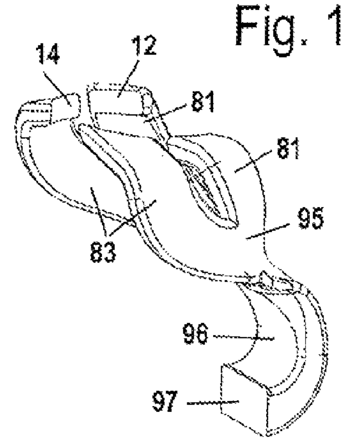

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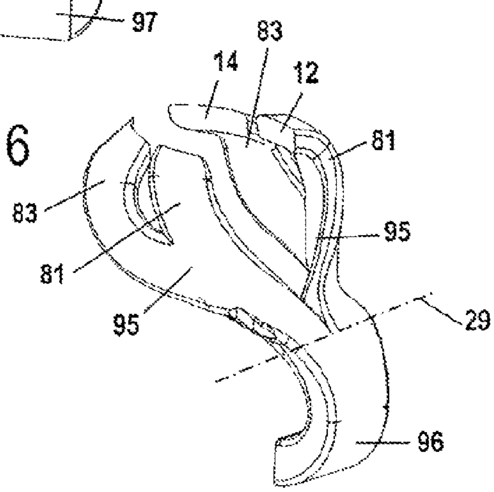

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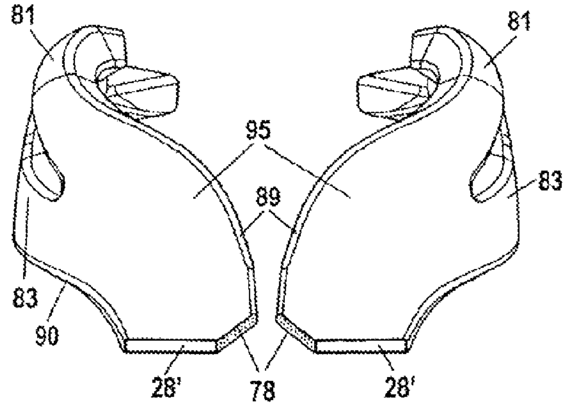

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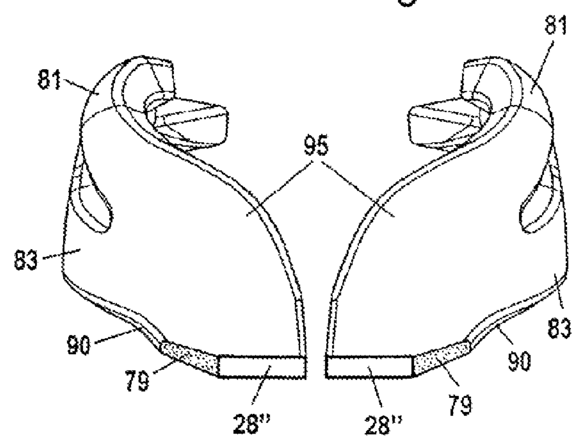

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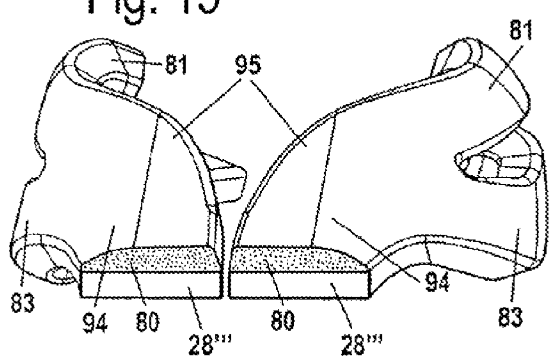

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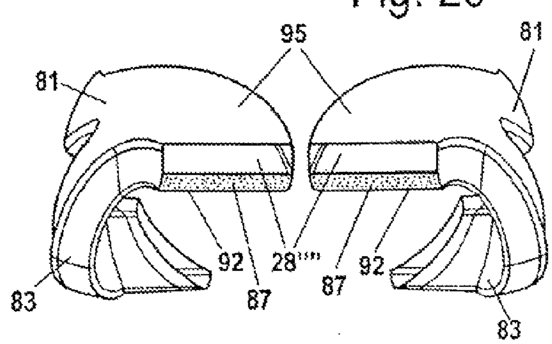

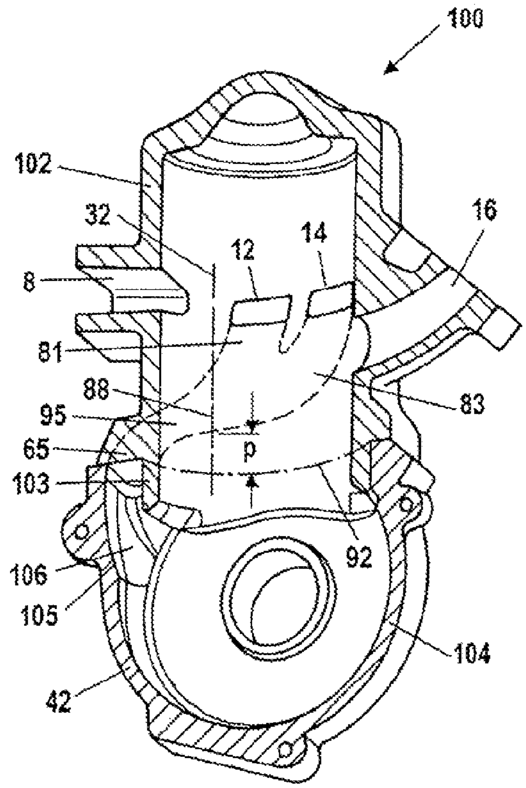
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Fig. 21

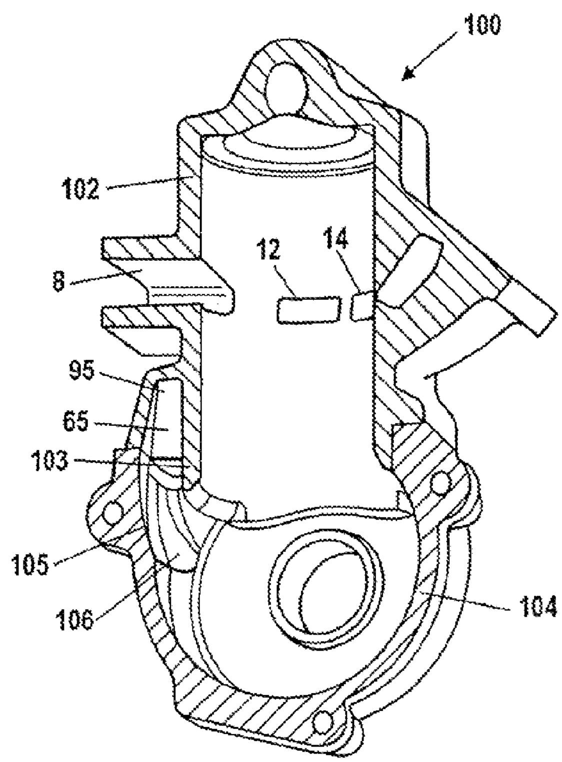
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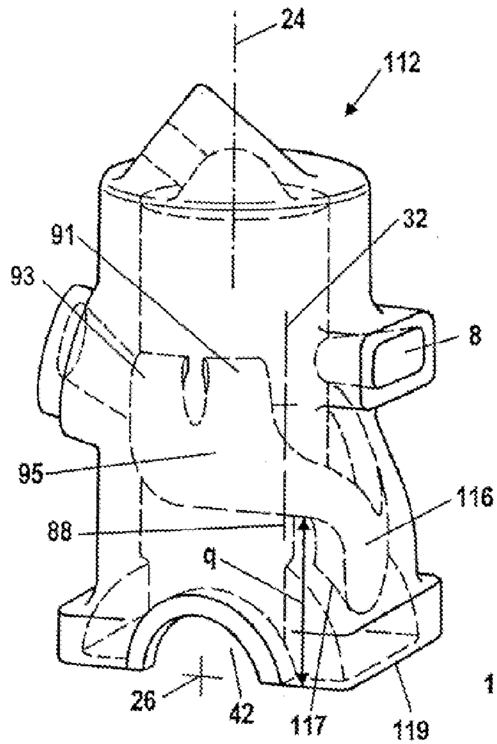
Fig. 22

Fig. 23



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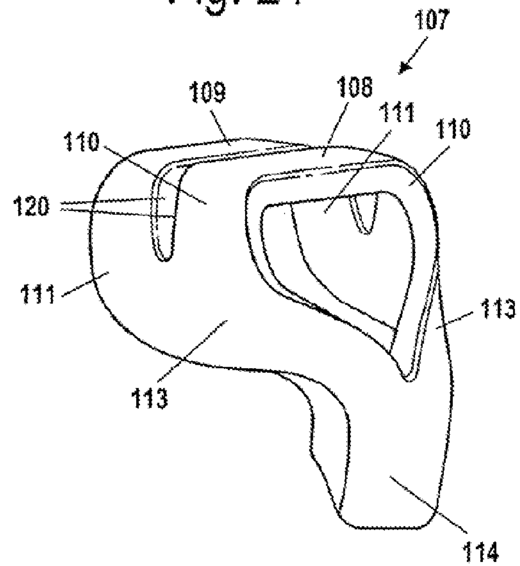


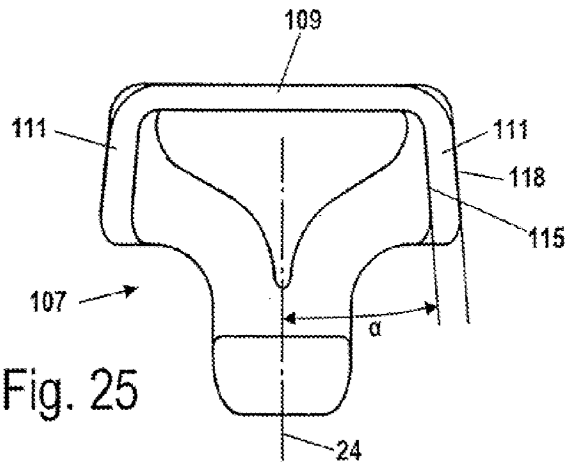
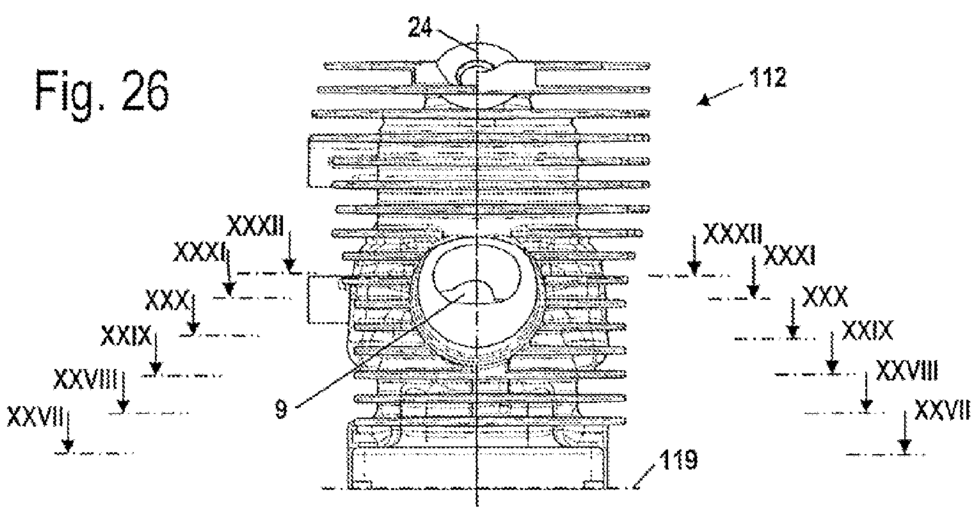


Fig. 25

Fig. 26



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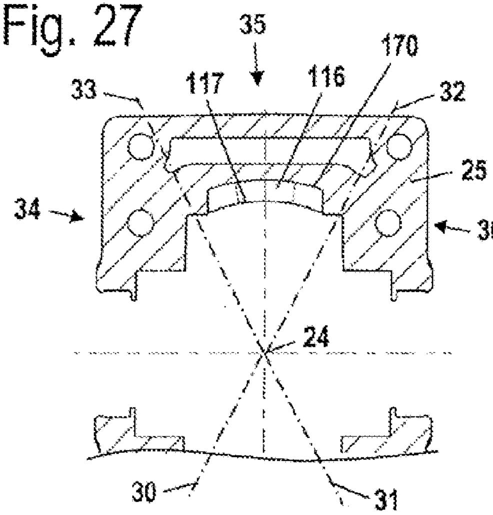

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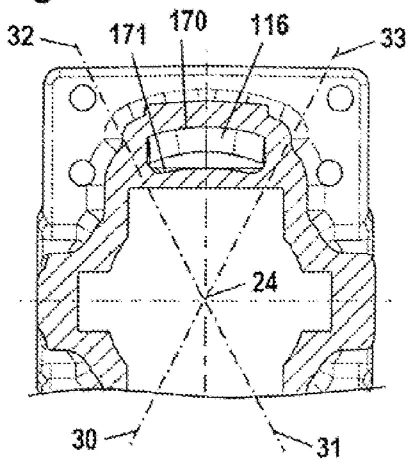

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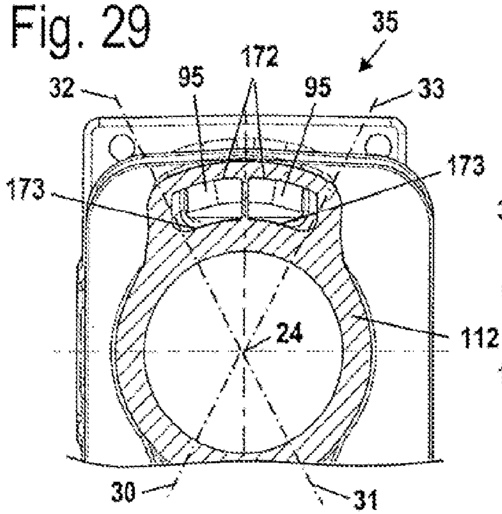

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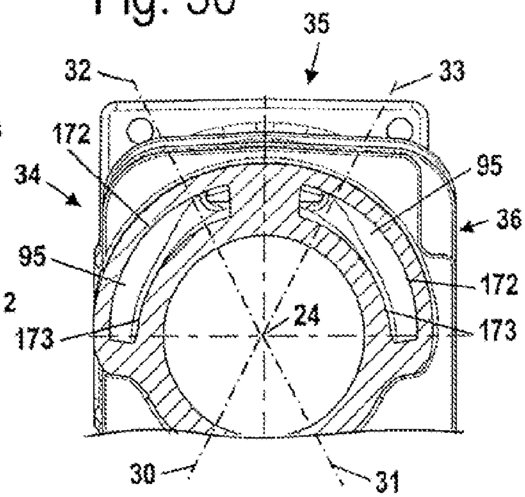

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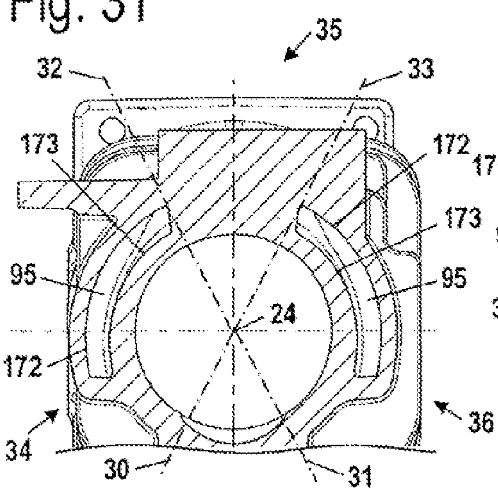

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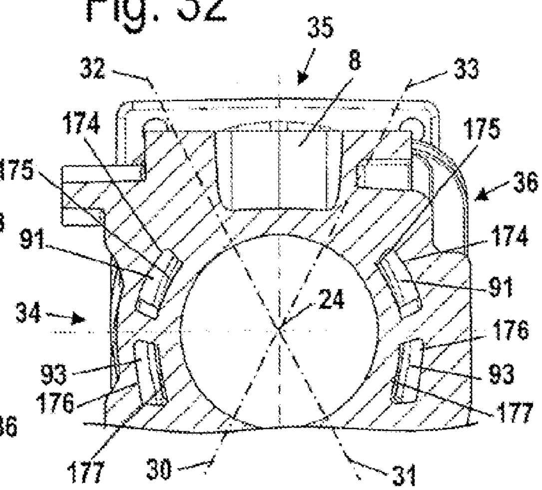

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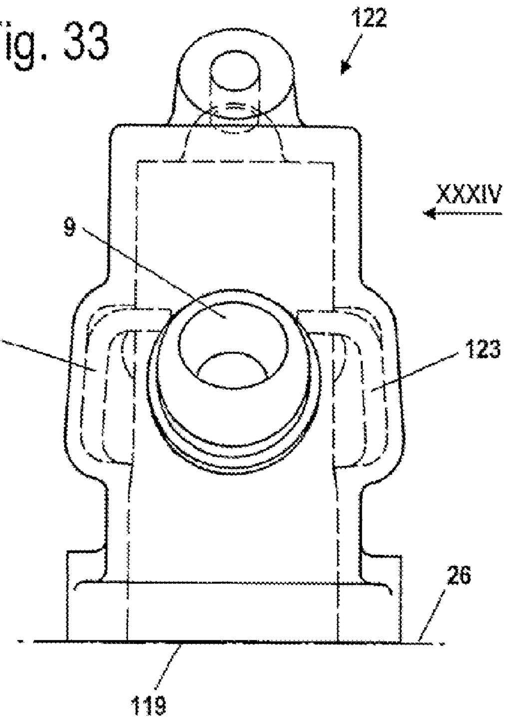

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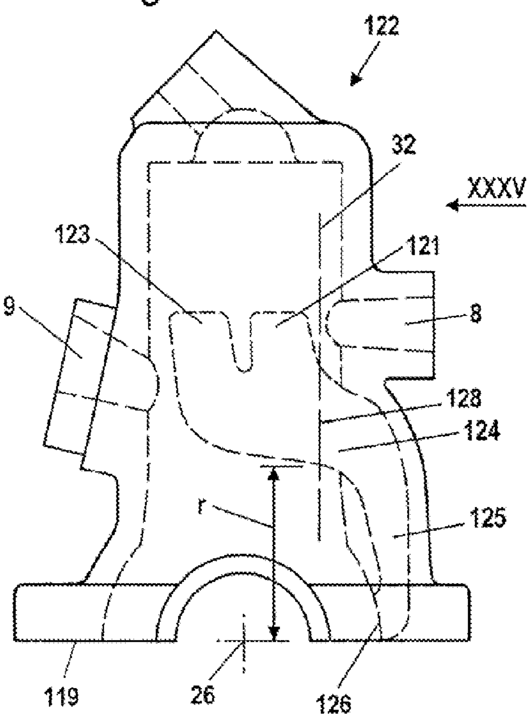

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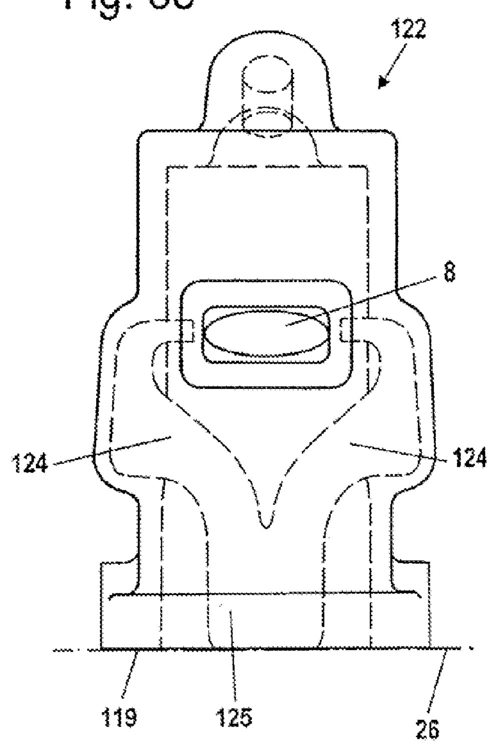

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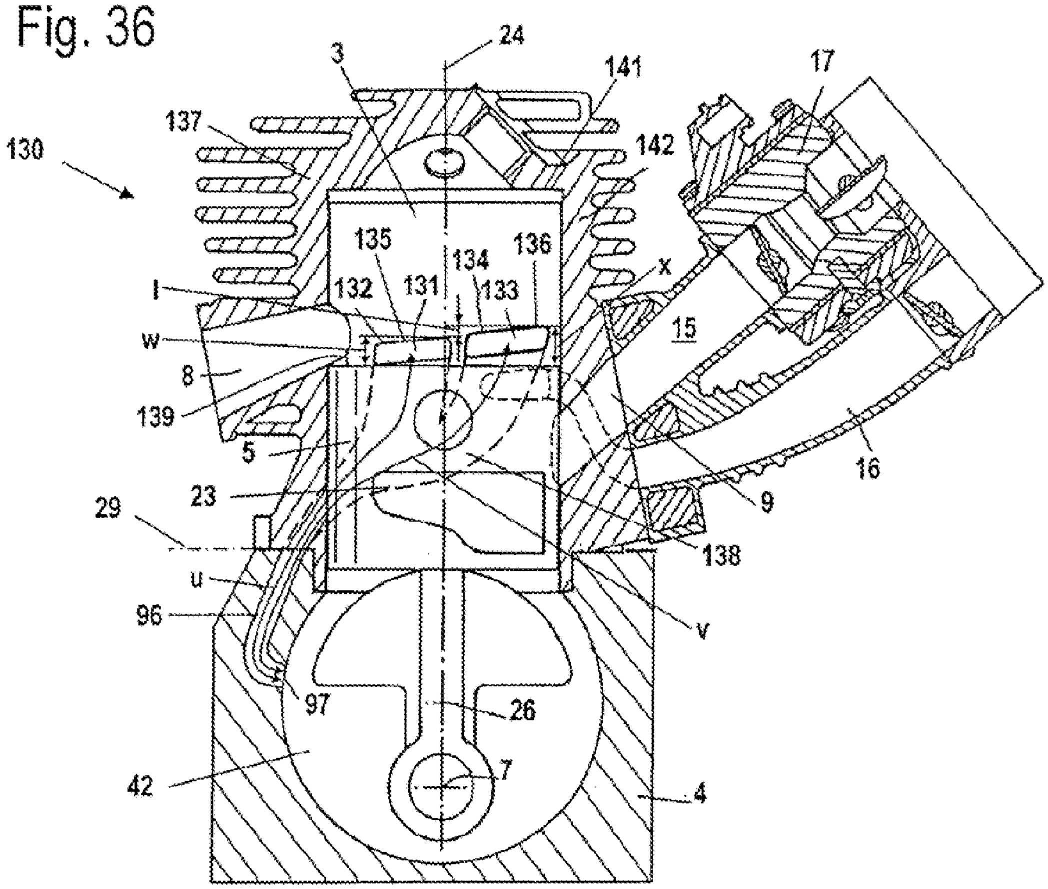
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Fig. 37

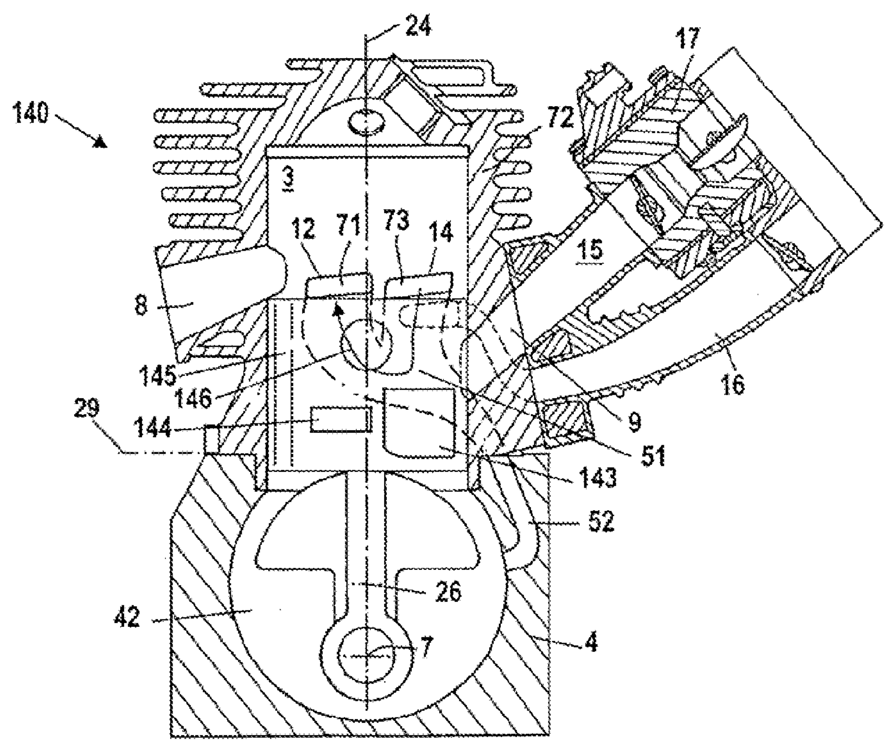
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Fig. 38

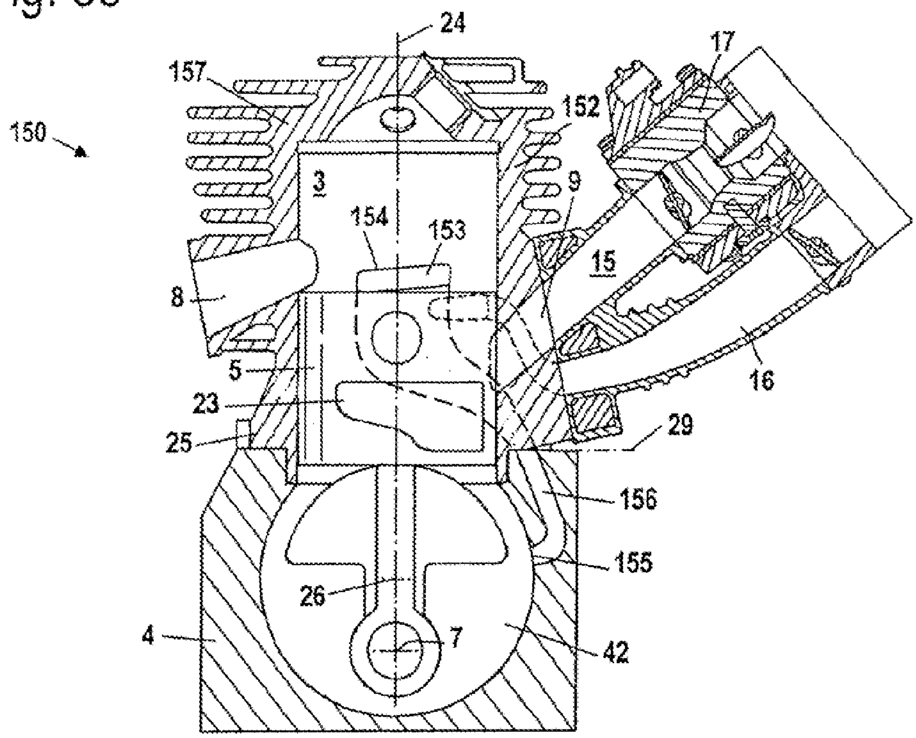
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Fig. 39

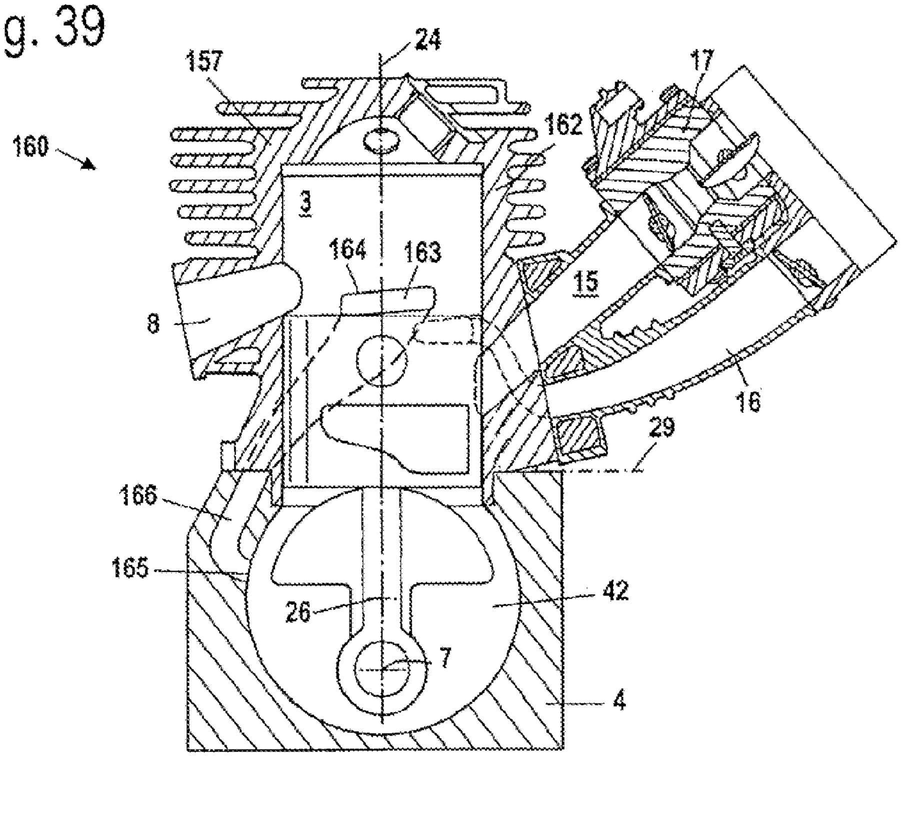
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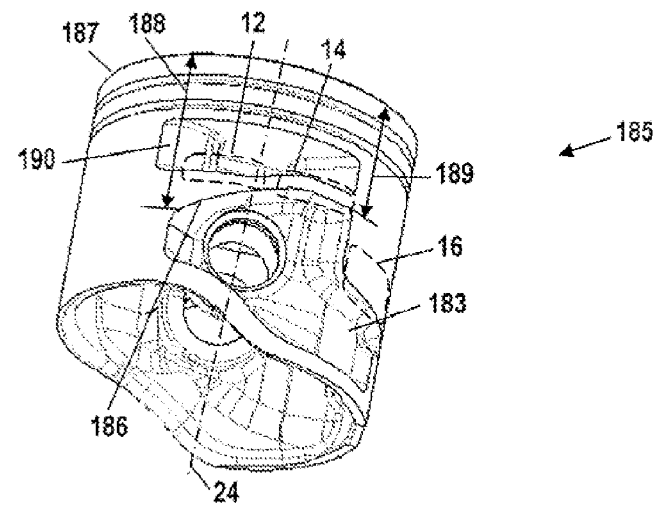
Fig. 40



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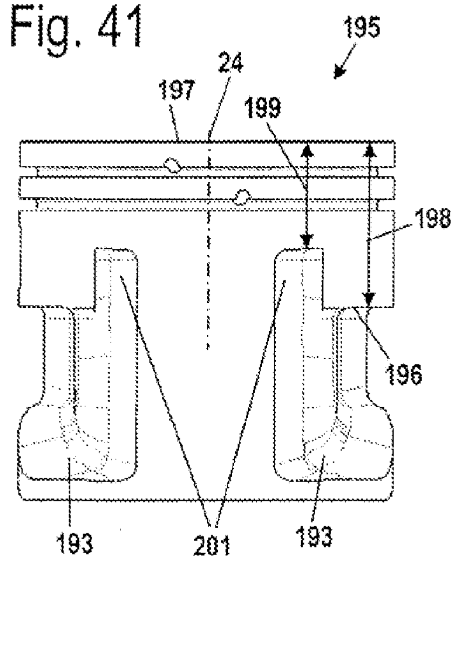
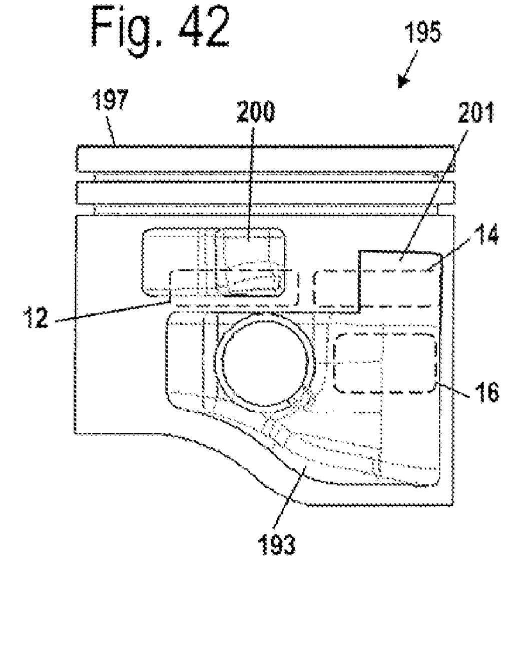


Fig. 42



TWO-STROKE ENGINE, SAND CORE FOR PRODUCING A TWO-STROKE ENGINE, AND METHOD FOR OPERATING A TWO-STROKE ENGINE

BACKGROUND OF THE INVENTION

The invention concerns a two-stroke internal combustion engine, a sand core for producing a two-stroke engine, and a method for operating a two-stroke internal combustion engine.

A two-stroke engine with oppositely arranged transfer passages is disclosed in EP 1 135 585 B1. The transfer passages are guided in the crankcase about the circumference of the crankshaft. In the cylinder the transfer passages are guided, coming from opposite cylinder sides, to a location below the outlet of the combustion chamber. In order to dispose both transfer passages within the crankcase, a separate insert is provided which separates the transfer passages from each other and from the crankcase interior.

The object of the invention is to provide a two-stroke engine that has a simple configuration and low exhaust gas values. Another object of the invention resides in providing a sand core for producing the two-stroke engine with which the two-stroke engine is producible in a simple way with minimal manufacturing tolerances. Another object of the invention resides in providing a method for operating a two-stroke engine with which low exhaust gas values are reached.

SUMMARY OF THE INVENTION

According to a first embodiment, this object is solved with regard to the two-stroke internal combustion engine (in the following referred to as two-stroke engine) by a two-stroke engine comprising a cylinder with a combustion chamber disposed therein that is delimited by a piston reciprocatingly supported in the cylinder, wherein the piston drives a crankshaft that is rotatably supported in a crankcase, wherein the crankcase in at least one position of the piston is connected with the combustion chamber by at least two transfer passages that each open by means of a piston-controlled transfer port into the combustion chamber, wherein the two-stroke engine has an inlet into the crankcase and an outlet from the combustion chamber, wherein the two-stroke engine is dividable into four sectors that extend parallel to the cylinder axis, wherein a first sector is provided with a transfer port of a first transfer passage, a second sector adjoining the first sector is provided with the outlet, a third sector adjoining the second sector is provided with a transfer port of a second transfer passage, and a fourth sector located between the first sector and the third sector, is provided with the inlet into the crankcase, and wherein the first and second transfer passages in the cylinder pass together, at a spacing to the separation plane between the cylinder and the crankcase, into a common sector adjoining the sector with the transfer ports.

It has been found that by the proposed arrangement of the transfer passages around the combustion chamber, in particular in a spiral shape, low exhaust gas values of the two-stroke engine can be achieved. The manufacture of the two-stroke engine can be simplified when both transfer passages are combined at their end connected to the crankcase. A common passage segment can thus be formed for a section of the transfer passages. Particularly when producing the two-stroke engine by pressure die casting only one sand core or a common core must be provided for the common passage segment.

Advantageously, both transfer passages are joined at the separation plane between cylinder and crankcase. Within the cylinder the transfer passages can be configured as separate passages. In the separation plane a common opening is provided for both transfer passages where both transfer passages pass into the crankcase. In the crankcase only a single passage must therefore be embodied for both transfer passages. This simplifies the production of the crankcase. However, it can be provided also that both transfer passages are already joined within the cylinder. In this connection, it can be provided that the transfer passages are embodied only within the cylinder and do not pass into the crankcase. However, it can be also provided that both transfer passages together pass into the crankcase. Since both transfer passages are joined in the cylinder, a common core for both transfer passages can be used for producing the cylinder by pressure die casting. In this way the precision with regard to the manufacture of the cylinder is improved. The inaccuracies which may originate from positioning of two individual sand cores relative to each other are avoided.

Advantageously, the radially outwardly positioned outer walls of the transfer passages and the radially inwardly positioned inner walls of the transfer passages are formed about at least one section of the length of the transfer passages as concentric circular segments relative to the longitudinal cylinder axis. The inner walls and the outer walls of the transfer passages thereby extend concentrically to the cylinder bore so that a constant spacing is provided between the inner walls and the outer walls as well as between the inner walls and the wall of the cylinder bore. In this way, material accumulations can be avoided in the cylinder. Over all, the cylinder can be constructed in a more compact configuration and with low weight. The production of the cylinder by means of a casting process is simplified on account of the concentric arrangement in that material accumulations are avoided. Moreover, it has been found that by limiting the transfer passages by circular segments concentrically positioned relative to the longitudinal cylinder axis good flow properties are achievable in the transfer passages that result in low exhaust gas values of the two-stroke engine. Advantageously, the inner walls and the outer walls extend in this connection about a large part of the length of the transfer passages as concentric circular segments relative to the longitudinal cylinder axis. Advantageously, the inner walls and the outer walls deviate from the circular segment shape only in the sections adjoining transfer ports. In this area the course of the transfer passages is selected advantageously such that favorable inflow angles result for a complete scavenging of the combustion chamber.

It is provided that the crankcase is formed of two half shells that have a joining plane extending parallel to the longitudinal cylinder axis. In this connection, the joining plane extends in particular perpendicularly to the axis of rotation of the crankshaft. Expediently, the transfer passages extend within the crankcase within the joining plane of the crankcase. In this way, the transfer passages can be produced by cores that are moveable parallel to the axis of rotation of the crankshaft. In this connection, the transfer passages can be separated from the crankcase interior by a wall section that is integrally formed with the crankcase. Separate components for the separation of the transfer passages from the crankcase interior can be eliminated. The production and assembly are thus simplified. The number of the required individual parts is reduced. A simple configuration also results when the transfer passages are formed in the crankcase by a depression embodied in the crankcase and a collar provided on the cylinder and projecting past the separation plane into the crankcase. An extension of the transfer passages into the crankcase can thus be achieved in an easy way, without additional components being needed.

Advantageously, the cylinder has four transfer ports and two transfer ports are arranged in the first sector and two transfer ports in the third sector of the two-stroke engine. Advantageously, two transfer passages are joined in the second sector and two transfer passages are joined in the fourth sector. In this connection, the two inlet-side transfer passages are guided advantageously below the inlet and the two outlet-side transfer passages below the outlet. Since the transfer passages are guided to a location below the inlet and below the outlet, the width of the two-stroke engine is reduced in the direction of the crankshaft axis. In the area of the crankshaft axis the cylinder bottom can be formed to be narrow. In case of two-stroke engines where the transfer passages extend approximately parallel to the longitudinal cylinder axis toward the crankcase, it is necessary to make available extra space for the transfer passages at the cylinder, the cylinder bottom, and the crankcase laterally of the crank webs. This extra width can be eliminated when the transfer passages are guided to a location below the inlet and the outlet.

However, it can be also provided that all four transfer passages are joined in the fourth sector, i.e. at the inlet side. Only a single passage segment must therefore be embodied in the crankcase for all four transfer passages. Advantageously, all four transfer passages are joined in the second sector. Since all four transfer passages extend to a location below the outlet, there is plenty of space available at the inlet side of the two-stroke engine. This provides favorable installation conditions. It has been found that the combustion chamber scavenging action is improved when the transfer passages are extended to a point below the outlet.

It is provided that two transfer passages whose transfer ports open within the same sector have different passage lengths. When disposing all transfer passages within a common sector, the different passage lengths result on account of the different distance of the transfer port to this sector. In case of two-stroke engines where two transfer passages each are guided toward the outlet and two transfer passages each are guided toward the inlet, it is possible by means of different configurations of the transfer passages to generate different transfer passage lengths in a targeted fashion in order to achieve in this way an improved combustion chamber scavenging action. Advantageously, the transfer passage that opens at the inlet-near transfer port is longer than the transfer passage that opens at the outlet-near transfer port. Advantageously, the two transfer ports arranged in the same sector have different control timing. In this connection, in particular the transfer port of the longer transfer passage, especially the transfer port close to the inlet, opens before the transfer port of the shorter transfer passage, advantageously before the transfer port close to the outlet. In case of a two-stroke engine where the transfer passage close to the inlet is longer, the scavenging action of the transfer passage close to the inlet takes correspondingly longer. To compensate this, it can be provided that the transfer passage close to the inlet opens earlier. In this way, turbulences can be avoided at the same time in the area where the two transfer passages join each other. A uniform scavenging action of the transfer passages can be achieved.

Advantageously, two transfer passages whose transfer ports open in the same sector are joined to a common passage. In this way, the two transfer passages that are arranged side by side in the same sector can be joined first and subsequently the two common passages extending on each side of the cylinder can be combined above the crankcase to a common channel. All four transfer passages of the two-stroke engine can thus open through a common channel into the crankcase. Advantageously, the transfer passages are joined at a distance to the separation plane of cylinder and crankcase to form a common channel. In this connection, the transfer passages are joined expediently in the sector in which the transfer ports of the transfer passages are arranged. Therefore, the transfer passages are already joined at a small distance behind the transfer port so that the transfer passages extend as a common channel for a considerable length.

It is provided that the two-stroke engine has a supply passage for the supply of scavenging air. Advantageously, the supply passage opens at the cylinder and the piston has a piston recess and the piston recess connects the supply passage with a transfer port close to the inlet while a transfer port close to the outlet is connected with the crankcase interior through the piston. Therefore, only the transfer passage close to the inlet is connected directly with the supply passage. Since both transfer passages arranged side by side are connected with each other, the transfer passage close to the outlet can be filled through the transfer passage dose to the inlet with scavenging air. A uniform filling and scavenging of the transfer passages can be achieved in this way. As a result of the communication with the crankcase interior, complete scavenging is possible.

When the transfer passages are connected with a supply passage for the supply of scavenging air, for unequal lengths of the transfer passages a non-uniform scavenging action can result. To avoid this, it is provided that in at least one position of the piston a transfer port is still sealed completely, while a neighboring transfer port, on the same side of the cylinder, is already connected through the piston recess with the supply passage. In this connection, in particular the transfer port that is arranged at the longer transfer passage is already connected with the supply passage. In case of the transfer passages extending below the outlet, particularly the transfer port close to the outlet is still sealed while the transfer port close to the inlet is already connected with the supply passage. In order to reach a uniform scavenging action of the transfer passages, it is in particular provided that the piston recess has an upper edge whose spacing to the piston bottom changes in circumferential direction of the piston. In case of two transfer ports to be connected with a piston recess, it is thus possible that one transfer port, in particular the transfer port assigned to the longer transfer passage, is scavenged first. By an appropriately adjusted arrangement of the upper edge of the piston recess it is possible that a uniform front of scavenging air results when the two transfer passages are joined.

However, an inclined or displaced upper edge of a piston recess can also be advantageous when only one transfer passage is connected with the piston recess. By means of a non-uniform upper edge of the piston recess, especially an edge that is inclined toward the longitudinal cylinder axis, it is possible to compensate length differences within a transfer passage in the circumferential direction. Thus, the area of the transfer passage that is arranged adjacent to the inlet in case of a transfer passage that is guided below the outlet can be connected first with the supply passage. A uniform scavenging air front can thereby be achieved in the transfer passages. Turbulence in the transfer passage can be avoided so that a good and complete scavenging of the transfer passage results.

In order to achieve a good combustion chamber scavenging action, it is provided that at least one transfer passage is guided in the cylinder such that the mouth at the cylinder bottom has a wide side extending parallel with the crankshaft axis and a narrow side that is measured perpendicularly thereto. Moreover, the length of the wide side decreases in cross-sections perpendicularly to the direction of flow toward the transfer port and the length of the narrow side increases in cross-sections perpendicularly to the direction of flow toward the transfer port. Known transfer passages are twisted when guided around the cylinder. Instead of twisting the passages, it is now provided to narrow continuously the wide side and to continuously widen the narrow side so that another shape of the transfer passage is formed at the transfer port.

A separation of the flow in the transfer passage can be avoided by the suggested design of the transfer passage. This is achieved in that the difference between the outer radius and the inner radius in the transfer passage can be kept minimal by the suggested design. In case of engines operating with scavenging air the exhaust gas values can be improved in this way because mixing of the scavenging air with fuel/air mixture can be avoided substantially.

In this connection, it is advantageous when in the cross-section that is neighboring the transfer port and is positioned perpendicularly to the direction of flow the length of the wide side is smaller than the length of the narrow side. When at the cylinder bottom the wide side is wider than the narrow side, i.e., the transfer passage in cross-section is elongate in the direction toward the axis of rotation of the crankshaft, the transfer passage neighboring the transfer port is oriented transversely to the axis of rotation of the crankshaft. In order to provide a transition that is favorable with respect to flow between the mouth at the cylinder bottom and the transfer passage, it is provided that the product of the length of the wide side and the length of the narrow side is roughly the same for every cross-section of the transfer passage perpendicular to the direction of flow.

With regard to the sand core the object is solved in that the sand core has sections that mold at least two transfer passages positioned in two opposed sectors of the two stroke engine of the first embodiment.

Since a single sand core is used for molding or forming at least two transfer passages arranged in opposed sectors is used, the position of the transfer passages relative to each other is fixed by the sand core. Tolerances are eliminated that are caused by positioning relative to each other separately embodied sand cores for the opposed transfer passages. Advantageously, a sand core is provided for molding all transfer passages in the cylinder.

Advantageously, the sand core has at least one connecting segment that connects those segments of the sand core with each other that mold the ends of the transfer passages that are arranged in opposite sectors and face the combustion chamber. The connecting segment is arranged in the area of the cylinder bore of the finished cylinder. By means of the connecting segment arranged in this area the stability of the sand core can be increased because the sand core connects the oppositely positioned transfer passages with each other at its end facing the crankcase as well as at its end facing the transfer ports.

With regard to the method, the object is solved with a method for operating a two-stroke engine that has a combustion chamber embodied in a cylinder which is delimited by a piston reciprocatingly supported in the cylinder and driving a crankshaft supported rotatably in a crankcase, wherein the crankcase is connected in at least one position of the piston by means of at least two transfer passages with the combustion chamber, which transfer passages open with a piston-controlled transfer port into the combustion chamber, respectively, wherein the two-stroke engine has an inlet into the crankcase and an outlet from the combustion chamber, wherein the two-stroke engine is dividable into four sectors extending parallel to the longitudinal cylinder axis, wherein in a first sector two transfer ports of the transfer passages are provided, wherein in a second sector adjoining the first sector the outlet is provided, and in a fourth sector, adjoining the other side of the first sector opposite the second sector, the inlet is provided, wherein the two transfer passages are joined to form a common channel, and a supply passage is provided for the supply of scavenging air which supply passage opens at the cylinder, and wherein the piston has a piston recess, it is provided that the transfer port of the inlet-near transfer passage is connected, in the area of the top dead center of the piston, by the piston recess with the supply passage; that scavenging air is supplied into the inlet-near transfer passage; and that through the inlet-near transfer passage the scavenging air is supplied into the outlet-near transfer passage.

Since only to one of the two transfer passages connected to each other scavenging air is supplied, a good, uniform scavenging action of the transfer passages can be achieved. Turbulences that may be generated in the connecting area of the transfer passages are avoided.

The object of the present invention is further solved according to a second embodiment with regard to the two-stroke engine by a two-stroke engine comprising a cylinder with a combustion chamber disposed therein that is delimited by a piston reciprocatingly supported in the cylinder, wherein the piston drives a crankshaft that is rotatably supported in a crankcase, wherein the crankcase in at least one position of the piston is connected with the combustion chamber by at least two transfer passages which transfer passages each open by means of a piston-controlled transfer port into the combustion chamber, wherein the two-stroke engine has an inlet into the crankcase and an outlet from the combustion chamber, wherein the two-stroke engine is dividable into four sectors that extend parallel to the cylinder axis, wherein a first sector is provided with two transfer ports of the transfer passages, a second sector adjoining the first sector is provided with the outlet, and a fourth sector that adjoins the first sector at a side remote from the second sector is provided with the inlet, and wherein the transfer passages are combined to a common channel, wherein a supply passage for supplying scavenging air is provided that opens at the cylinder and wherein the piston has a piston recess, wherein the piston recess is arranged in the area of the transfer port of the inlet-near transfer passage and does not extend into the area of the transfer port of the outlet-near transfer passage.

With the second embodiment of a two-stroke engine as set forth, a scavenging action of the outlet-near transfer passage through the inlet-near transfer passage is realized in an easy way.

The object is further solved according to a third embodiment with regard to the two-stroke engine by a two-stroke engine comprising a cylinder with a combustion chamber disposed therein that is delimited by a piston reciprocatingly supported in the cylinder, wherein the piston drives a crankshaft that is rotatably supported in a crankcase, wherein the crankcase in at least one position of the piston is connected with the combustion chamber by at least two transfer passages which transfer passages each open by means of a piston-controlled transfer port into the combustion chamber, wherein the two-stroke engine has an inlet into the crankcase and an outlet from the combustion chamber, wherein the two-stroke engine has a center plane in which the longitudinal cylinder axis is positioned and that divides the outlet, wherein the transfer ports of the two transfer passages are positioned on one side of the center plane, and wherein the two-stroke engine has a supply passage for supplying scavenging air, wherein the two transfer passages are combined to a common channel and wherein the transfer ports upon downward stroke of the piston open sequentially (one after the other) toward the combustion chamber.

With the third embodiment of a two-stroke engine as set forth above, a uniform scavenging action of the transfer passages can be achieved. The different control timing enables compensation of different pressure conditions in the transfer passages on the basis of different transfer passage lengths and avoidance of turbulences in the area where the two transfer passages are connected with each other by the different control timing of the two transfer passages.

It is provided that the piston has a planar piston bottom and that the control edges of the transfer ports facing the combustion chamber top have different spacings to the piston bottom at bottom dead center of the piston. Different control timing of the transfer passages can be realized easily in this manner. Advantageously, at bottom dead center of the piston the distance of the control edge of the inlet-near transfer passages to the piston bottom is greater than the distance of the control edge of the outlet-near transfer passage to the piston bottom. With this configuration, the inlet-near transfer passage opens before the outlet near transfer passage.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention are explained in the following with the aid of the drawing.

FIG. **1** is a schematic section representation of a two-stroke engine.

FIG. **2** is a schematic illustration of the cylinder of the two-stroke engine of FIG. **1** at the cylinder bottom.

FIG. **3** is a schematic illustration of the two-stroke engine of FIG. **1**.

FIG. **4** is a perspective illustration of the transfer passages of the two-stroke engine of FIG. **1**.

FIG. **5** is a schematic side view of an embodiment of the transfer passages of the two-stroke engine of FIG. **1**.

FIG. **6** is a schematic section illustration of an embodiment of a two-stroke engine.

FIG. **7** a perspective representation of a half shell of the crankcase of the two-stroke engine of FIG. **6**.

FIG. **8** shows a cylinder of a two-stroke engine in a perspective representation.

FIG. **9** is a side view of the cylinder of FIG. **8**.

FIG. **10** is a section view along the section line X-X of FIG. **9**.

FIG. **11** is a side view of the transfer passages of the cylinder of FIGS. **8** to **10**.

FIG. **12** is a side view in the direction of arrow XII of FIG. **11**.

FIG. **13** a plan view of the transfer passages in the direction of the arrow XIII in FIG. **11**.

FIG. **14** is a first perspective representation of an embodiment of transfer passages.

FIG. **15** is a second perspective representation of an embodiment of transfer passages.

FIG. **16** is a third perspective representation of an embodiment of transfer passages.

FIG. **17** is a perspective representation of one embodiment of transfer passages with a constricted opening cross-section.

FIG. **18** is a perspective representation of another embodiment of transfer passages with a constricted opening cross-section.

FIG. **19** is a perspective representation of yet another one embodiment of transfer passages with a constricted opening cross-section.

FIG. **20** is a perspective representation of yet another embodiment of transfer passages with a constricted opening cross-section.

FIG. **21** is a perspective section illustration of an embodiment of a two-stroke engine, the section taken centrally through the outlet.

FIG. **22** shows the two-stroke engine of FIG. **21** in a section view where the section line is off-center relative to the outlet.

FIG. **23** is a schematic, perspective representation of a cylinder of a two-stroke engine,

FIG. **24** is a perspective representation of a sand core for producing the transfer passages of the cylinder of FIG. **23**,

FIG. **25** is a side view of the sand core of FIG. **24**,

FIG. **26** is a side view of the cylinder of FIG. **23**.

FIG. **27** is a section along the section line XXVII-XXVII of FIG. **26**.

FIG. **28** is a section along the section line XXVIII-XXVIII of FIG. **26**.

FIG. **29** is a section along the section line XXIX-XXIX of FIG. **26**.

FIG. **30** is a section along the section line XXX-XXX of FIG. **26**.

FIG. **31** is a section along the section line XXXI-XXXI of FIG. **26**.

FIG. **32** is a section along the section line XXXII-XXXII of FIG. **26**.

FIG. **33** is a schematic representation of a cylinder of a two-stroke engine in a side view.

FIG. **34** is a side view in the direction of the arrow XXXIV of FIG. **33**.

FIG. **35** is a side view in the direction of the arrow XXXV of FIG. **34**.

FIG. **36** is a schematic section illustration of another embodiment of a two-stroke engine.

FIG. **37** is a schematic section illustration of another embodiment of a two-stroke engine.

FIG. **38** is a schematic section illustration of another embodiment of a two-stroke engine.

FIG. **39** is a schematic section illustration of another embodiment of a two-stroke engine.

FIG. **40** is a perspective representation of an embodiment of a piston,

FIG. **41** is a side view of an embodiment of a piston.

FIG. **42** is another side view of an embodiment of a piston.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** shows a two-stroke engine **1** in a schematic illustration which has a cylinder **2** in which a combustion chamber **3** is embodied. The two-stroke engine **1** is in particular arranged in a hand-guided power tool like a motor chain saw, a cut-off machine, or the like and serves for driving the tool of the power tool. The combustion chamber **3** is delimited by a piston **5** that is supported in the cylinder **2** so as to reciprocate in the direction of longitudinal cylinder axis **24**. The piston **5** drives by connecting rod **6** a crankshaft **7** supported rotatably in a crankcase **4** about axis of rotation **26**. The combustion chamber **3** fluidically communicates through a total of four transfer passages **11**, **13** with the crankcase interior **42** at bottom dead center of the piston **5**, as shown in FIG. **1**. At the cylinder **2** a mixture channel **15** with a mixture inlet **9** opens. The two-stroke engine **1** is embodied symmetrically to a center plane **48** that represents the section plane of FIG. **1**. At the cylinder **2** a supply passage **16** in which scavenging air substantially free of fuel is guided opens below a transfer port **14** of the transfer passage **13** neighboring the mixture inlet **9**.

The supply passage **16** branches in the area of a connection flange **77** of the cylinder **2** into two branches that each open with a supply passage inlet **10** at the cylinder **2** at the side of a transfer port **14** facing the crankcase **4**. An outlet **8** is provided at the combustion chamber **3**. The transfer passages **11** neighboring or proximal to the outlet **8** open with transfer ports **12** into the combustion chamber **3**.

The mixture channel **15** and the supply passage **16** are connected to an air filter **22**. The mixture channel **15** is connected through a carburetor **17** with the air filter **22**. In the carburetor **17** fuel is supplied to the combustion air that has been sucked in through the air filter **22**. In the carburetor **17** a throttle valve **18** and upstream of the throttle valve **18** a choke flap **19** are pivotably supported. The supply passage **16** is connected with a supply passage component **20** to the air filter **22**. In the supply passage component **20** a control flap **21** is pivotably supported and controls the amount of scavenging air supplied to the two-stroke engine **1**. The position of the control flap **21** may be coupled to the position of the throttle valve **18**. The mixture channel **15** and the supply passage **16** are embodied between the carburetor **17** or the supply passage component **20** and the connecting flange **77** in a common connecting socket **58**.

As shown in FIG. **3**, the cylinder **2** is connected at a separation plane **29** with the crankcase **4**. As shown in FIG. **3**, the crankcase **4** comprises two crankcase shells **45** and **46** that are connected with each other at a joining plane **47**. The joining plane **47** extends perpendicularly to the axis of rotation **26** of the crankshaft **7** and perpendicularly to the separation plane **29**. In the illustrated embodiment, the joining plane **47** extends within the center plane **48**. However, the joining plane **47** can be arranged relative to the center plane **48** so as to be displaced in parallel.

As shown in FIGS. **1** to **3**, the outlet-near transfer passages **11**, i.e., proximal to the outlet and remote from the inlet, are guided in the cylinder **2** spirally around the cylinder **2** below the outlet **8**. At the cylinder bottom **25** the transfer passages **11** open each with a mouth **27**. Both mouths **27** are joined at the cylinder bottom **25** to a common opening. In the crankcase **4** both transfer passages **11** are guided in a common passage segment **40** that opens with an opening **43** into the crankcase interior **42**. In the common passage segment **40** no separation is provided between both outlet-near transfer passages **11**. The common passage segment **40** can therefore be produced in a simple way.

The inlet-near transfer passages **13**, i.e., proximal to the inlet and remote from the outlet, are joined below the mixture inlet **9**. The inlet-near transfer passages **13** are guided spirally around the cylinder **2** below the mixture inlet **9**. Each transfer passage **13** opens with a mouth **28** at the cylinder bottom **25**. Both mouths **28** are joined at the cylinder bottom **25** to a common opening. In the crankcase **4** the two inlet-near transfer passages **13** are guided in a common passage segment **41** that extends in the joining plane **47** between the two crankcase shells **45** and **46** and opens with an opening **44** into the crankcase interior **42**.

As shown in FIG. **2**, the outlet **8** and the mixture inlet **9** are arranged on opposite sides of the cylinder **2**. Between the outlet **8** and the mixture inlet **9** there are on the inner circumference of the cylinder **2** a transfer port **12** and a transfer port **14**, respectively. The cylinder **2** may be divided by four imaginary dividing planes **30**, **31**, **32**, **33** that extend parallel to the longitudinal cylinder axis **24** and contain the longitudinal cylinder axis **24**, respectively, into four imaginary sectors **34**, **35**, **36**, **37**. In this connection, the first sector **34** contains two transfer ports **12**, **14**. In the schematic view of the cylinder **2** from below shown in FIG. **2** a second sector **35** follows in counterclockwise direction and contains the outlet **8**. This sector **35** is adjoined by a third sector **36** that relative to the center plane **48** is symmetric to the first sector **34**. Between the third sector **36** and the first sector **34** a fourth sector **37** is arranged which is delimited by the dividing planes **30** and **31**. In this connection, the outlet **8**, the mixture inlet **9**, and the transfer ports **12**, **14** are arranged in each case completely within the sectors **34**, **35**, **36**, **37** and are not intersected by the dividing planes **30**, **31**, **32**, **33**.

The transfer passage **11** arranged in the first sector **34** passes at a junction **38** through the imaginary dividing plane **33** from the first sector **34** into the second sector **35**. Likewise, the outlet-near transfer passage **11** that opens in the third sector **36** passes at junction **38** through the dividing plane **32** from the third sector **36** into the second sector **35**. As shown in FIG. **1**, each junction **38** has relative to the separation plane **29** a distance a that is measured parallel to the longitudinal cylinder axis **24**. Therefore, the transfer passages **11** enter above the separation plane **29** the second sector **35** that encompasses the outlet **8**. The transfer passages **11** are not guided around the circumference of the cylinder **2** in the separation plane **29** but extend instead in a spiral shape within the cylinder **2**. Accordingly, both inlet-near transfer passages **13** pass from the first sector **34** or the third sector **36** at junctions **39** through the dividing plane **30** or the dividing plane **31** into the fourth sector **37**. The junctions **39** have, as shown in FIG. **1**, a distance b to the separation plane **29** that is measured parallel to the longitudinal cylinder axis **24**. The inlet-near transfer passages **13** also pass above the separation plane **29** into the fourth sector **37**.

The spiral extension of the transfer passages results in favorable flow properties. It has been found that by this configuration of the transfer passages **11**, **13** the exhaust gas values of the two-stroke engine **1** can be clearly improved. Moreover, material accumulations on the cylinder **2** are avoided by the spiral-shaped course of the transfer passages **11**, **13** so that a low weight of the two-stroke engine **1** results. Since the transfer passages in the crankcase **4** extend below the mixture inlet **9** and the outlet **8**, the cylinder bottom **25** can be made narrow in the direction of the axis of rotation **26**. Below mixture inlet **9** and outlet **8** enough space must be available at the cylinder bottom **25** for the mouths **27** and **28**. However, enough space is available in this area anyway because of the provided arrangement of mixture inlet **9** and outlet **8**. The two-stroke engine **1** can therefore be of a compact configuration and can be provided with minimal width.

In operation of the two-stroke engine **1** in the area of the top dead center of the piston **5** fuel/air mixture is sucked in through the mixture inlet **9** into the crankcase interior **42**. In this position of the piston **5** the supply passage inlet **10** is connected by piston recess **23** arranged on the outer periphery of the piston with the transfer ports **12** and **14**. In this connection, the piston **5** is provided in the first sector **34** as well as in the third sector **36** with a piston recess **23**, respectively, for the transfer ports **12**, **14** arranged in this area. Through the piston recess **23** scavenging air from the supply passage **16** is supplied to the transfer passages **11** and **13**. With the downward stroke of the piston **5** the fuel/air mixture is compressed in the crankcase **42**. As soon as the transfer ports **12** and **13** are opened by the piston **5**, scavenging air flows first from the transfer passages **11** and **13** into the combustion chamber **3** and scavenges exhaust gases from the preceding cycle from the combustion chamber **3** through the outlet **8**. Subsequently, fresh mixture flows from the crankcase interior **42** into the combustion chamber **3**. With the upward stroke of the piston **5** the fuel/air mixture is compressed in the combustion chamber **3** and is ignited in the area of the top dead center of the piston **5** by a spark plug, not shown. The piston **5** is accelerated by the ignition in the direction of the crankcase **4**. As soon as the outlet **8** opens, exhaust gases can stream out from the combustion chamber **3**. Residual gases are scavenged by the incoming scavenging air as soon as the transfer ports **12** and **14** open. Subsequently, fresh mixture flows in for the next cycle.

When scavenging air is supplied, the transfer passages **11** and **13** are flowed through from the transfer ports **12** and **14** in the direction of the crankcase **4**. In this connection, the transfer passages **11**, **13** are advantageously so designed that no scavenging air will pass into the crankcase **4**. When mixture passes from the crankcase **4** into the combustion chamber **3**, the transfer passages **11**, **13** are flowed through in opposite direction. In order to obtain a sufficient fill of the transfer passages with scavenging air at the usually very high engine speeds of the two-stroke engine **1** and to introduce at the same time a sufficient amount of fuel/air mixture into the combustion chamber **3**, the transfer passages **11**, **13** have a favorable fluidic design. Moreover, the transfer passages **11**, **13** are so formed that a separation of the flow is avoided in the transfer passages **11**, **13**. In this way, the scavenging air flowing into the transfer passages **11**, **13** fills out the entire cross-section of the transfer passages **11**, **13**. This provides for a good separation of the fresh mixture from the exhaust gases in the combustion chamber **3**.

The design of the transfer passages **11**, **13** is shown in FIG. **4**. Here only the contour of the transfer passages **11**, **13** is shown. The fluidically favorable extension is illustrated with the aid of an inlet-near transfer passage **13**. The outlet-near transfer passages **11** are embodied accordingly. As shown in FIG. **4**, the transfer passages have at the mouth **28** an elongate cross-section. In this connection, the mouths **28** are oriented in the direction of the axis of rotation **26** (FIG. **1**). The transfer passages **13** have at the mouth **28** a wide side **53** which has a length c. The wide side **53** is measured in parallel to the axis of rotation **26**. Perpendicularly thereto the transfer passages **13** have a narrow side **54** which has a length d. The length d is considerably smaller than the length c.

In FIG. **4** the direction of flow **59** in the transfer passages **13** is shown schematically. Moreover, several cross-sections **55**, **56** that are perpendicular to the direction of flow **59** are shown. As shown in FIG. **4**, the length d of the narrow side **54** increases continuously from the mouth **28** to the transfer port **14**, while the length c of the wide side **53** continuously decreases. In a cross-section **55** which is positioned between the mouth **28** and the transfer port **14**, the wide side **53** has a length e that is a little smaller than a length f of the narrow side **54**. In a cross-section **56** that is neighboring the transfer port **14**, the wide side **53** has a length g which is significantly smaller than a length h of the narrow side **54**. In this connection, the wide side **53** is positioned approximately in the direction toward the longitudinal cylinder axis **24** (FIG. **1**). In order to achieve a steady transition from the mouth **28** to the transfer port **14**, it is provided that the product of the length c, e, g of the wide side **53** and of the length d, f, h of the narrow side **54** of each cross-section **55**, **56** is constant. Between the mouth **28** and the cross-section **56** neighboring the transfer port **14**, the transfer passage **13** has a cross-section in which the length of the wide side **53** and the length of the narrow side **54** are the same.

In order to achieve a good tuning of the two-stroke engine **1**, the lengths of the transfer passages **11** and **13** can be embodied differently. This is shown FIG. **5**. Here two outlet-near transfer passages **61** are provided that each have a length k. Two inlet-near transfer passages **63** have a length l that is considerably smaller than the length k of the outlet-near transfer passages **61**. The outlet-near transfer passages **61** open with an opening **62** into crankcase interior **42**, schematically shown in FIG. **5**. The opening **62** is arranged, viewed in the direction of the longitudinal-cylinder axis **24**, below the axis of rotation **26** of the crankshaft **7**. The inlet-near transfer passages **63** open with an opening **64** into the crankcase interior **42** which opening is arranged above the axis of rotation **26**. It has been found that for achieving high engine speeds short transfer passages **63** are favorable, while for achieving high torque long transfer passages **61** are advantageous. Over all improved running behavior of the two-stroke engine **1** can be achieved by the combination of short and long transfer passages. Moreover, by suitable tuning of the lengths of the transfer passages **61**, **63**, the amount and distribution of the scavenging air within the transfer passages can be controlled.

As shown in FIG. **1**, the transfer passages **11** and **13** extend in the crankcase **4** at a distance to the crankcase interior **42**. The common passage segments **40** and **41** are separated from the crankcase interior **42** by webs **49** or **50** that are integrally formed in the crankcase **4**. In this connection, a section of web **49**, **50** can be provided on the crankcase shell **45** and the other section of the web **49**, **50** can be provided on the crankcase shell **46**, each section being integrally formed. However, it can also be provided to integrally form the entire web **49**, **50** on one of the crankcase shells **45** or **46**.

In FIG. **6**, another embodiment of a two-stroke engine **70** is shown. The configuration of the two-stroke engine **70** corresponds essentially to the configuration of the two-stroke engine **1** of FIG. **1**. Same reference numerals identify the same components. The two-stroke engine **70** has two outlet-near transfer passages **71** that open with transfer ports **12** into the combustion chamber **3** as well as two inlet-near transfer passages **73** that open with transfer ports **14** into the combustion chamber **3**. The combustion chamber **3** is embodied in a cylinder **72** of the two-stroke engine **70**. As shown in FIG. **6**, all transfer passages **71**, **73** are guided below the mixture inlet **9**. In this connection, two neighboring transfer passages **71**, **73** are already joined in the cylinder **72** to a common channel **51**. In FIG. **6**, the common channel **51** extends from the first sector **34** (FIG. **2**) to the fourth sector **37**. On the opposite side of the cylinder **72**, not shown, a channel **51** that is mirror-symmetrically embodied extends from the third sector **36** to the fourth sector **37**. The common channel **51** extends in a spiral shape in the cylinder **72** below the mixture inlet **9**. In the crankcase **4** all transfer passages **71**, **73**, i.e., both channels **51**, extend in a common passage segment **52** that opens with an opening **69** into the crankcase interior **42**. It may also be provided to have the two channels **51** extend separately in the crankcase **4**. In this connection, a seal arranged between both crankcase shells **45**, **46** can serve as a separation, for example.

FIG. **7** shows the constructive design of the second crankcase shell **46**. The first crankcase shell **45** is embodied symmetrically thereto for a central division of the crankcase **4**. The crankcase shell **46** has an insert **74** in which the common passage segment **52** is embodied. On the insert **74** a section of a web **75** is integrally formed which separates the common passage segment **52** from the crankcase interior **42**. However, the area embodied on the insert **74** can be embodied also as a one-piece configuration with the crankcase shell **46**. The crankcase **4** is produced advantageously by a casting process. Since the transfer passages **71**, **73** in the crankcase **4** extend in the common passage segment **52**, the crankcase shells **45**, **46** can be removed from the mold in the direction of the axis of rotation **26** of the crankshaft, without this requiring additional cores or the like for producing the common passage segment **52**. A simplified production of the crankcase **4** is thus provided. Likewise, the common passage segments **40** and **41** of the two-stroke engine **1** of FIG. **1** can be produced in a simple way as a one-piece configuration with the crankcase shells **45** and **46**. This simplified production is also possible when the channels **51** in the crankcase **4** are separated from one another by a seal arranged between the crankcase shells **45** and **46**.

FIGS. **8** to **10** show one embodiment of a cylinder **82**. The cylinder **82** has a connecting flange **57** for connecting to a connecting socket **58** (FIG. **1**). The mixture channel **15** and the supply passage **18** that is split into two branches open at the connecting flange **57**. In the cylinder **82**, an outlet-near transfer passage **81** and an inlet-near transfer passage **83** extend on each side of the cylinder **82**, respectively. The transfer passages **81** and **83** that are arranged in a common sector of the cylinder **82** are joined to a common channel **95**. In the area that adjoins the transfer ports **12**, **14** the transfer passages **81** and **83** are separated by a partition **86** from each other. The partition **86** ends at a distance s above the separation plane **29**. In this connection, the distance s is greater than the length of the partition **86** so that the transfer passages **81** and **83** extend together about most of their length.

In the cylinder **82** the inner contour of the transfer passages **81** and **83** that is facing the cylinder interior is molded or formed. Toward the exterior the transfer passages **81** and **83** in the cylinder **82** are embodied to be open. The cylinder **82** has on each cylinder side a connecting flange **85** to which the lids **84** shown in FIGS. **9** and **10** can be connected. Each lid **84** seals the two transfer passages **81** and **83** that are arranged adjacent to each other as well as the common channel **95**.

As shown in FIG. **10**, on the cylinder **82** a wall **65** is integrally formed which separates the common channels **95** on each side of the cylinder **82** from each other. The wall **65** ends at the separation plane **29**. In the separation plane **29** the common channels **95** are joined. Since the common channels **95** pass at the cylinder bottom **25** into the crankcase **4** below the outlet **9**, the width z of the cylinder bottom **25** shown in FIG. **10** is considerably smaller than the length y shown in FIG. **9** of the cylinder bottom **25**. In this connection, the length y is measured perpendicular to the axis of rotation **26** and the width z parallel to the axis of rotation **26** of the crankshaft **7**.

FIGS. **11** to **16** show the design of the transfer passages **81** and **83**. In this connection, FIGS. **11** to **13** show a first design and FIGS. **14** to **16** show a second design. In the design of the transfer passages **81** and **83** shown in FIGS. **11** to **13**, the transfer passages **81** and **83** are separated only about a short section of their length. As shown in FIG. **12**, the outlet-near transfer passages **81** have a length t that is a little smaller than the length m of the inlet-near transfer passages **83**. The common channel **95** together with the common passage segment **96** in the crankcase **4** of the two channels **95** has a length n which amounts to about 10% up to about 70% of the length m of the inlet-near transfer passage **83**. The length o of the common passage segment **96** amounts advantageously to about 5% up to about 70% of the length m of the inlet-near transfer passage **83**. The common passage segment **96** opens with an opening **97** into the crankcase interior **42**.

As shown in particular in FIGS. **11** and **12**, the common channel **95** has a section **98** adjoining the separation plane **29** in which the walls delimiting the common channel **95** extend approximately perpendicularly to the separation plane **29** or open slightly toward the separation plane **29**. In this way, this segment **98** of the transfer passages **81**, **83** can be molded with a core when producing the cylinder **82** by pressure die casting.

In the design of the transfer passages **81** and **83** illustrated in FIGS. **14** to **16**, the transfer passages **81** and **83** are embodied in a twisted shape up to the separation plane **29**. The transfer passages **81**, **83** extend approximately concentrically around the cylinder bore.

FIGS. **17** to **20** show further embodiments of the transfer passages **81** and **83**. FIG. **17** shows transfer passages **81** and **83** that open with mouths **28'** into the crankcase; the mouths **28'** have, compared with the mouths **28** (FIG. **10**), a reduced cross-section. For this purpose, in the area of the mouths **28'** there are slanted walls **78** that are arranged at inwardly positioned side walls **89** of the transfer passages **81** that are facing each other. By means of the walls **78** a reduced effective flow cross-section of the common channels **95** and thus a lower throughput of the two-stroke engine results. By means of the walls **78** it is possible to enable designs of the transfer passages **81**, **83** for two-stroke engines with different engine displacements. The adaptation of the effective flow cross-section of the transfer passages **81**, **83** to the engine displacement of the internal combustion engine can be realized by means of suitable sizing of the walls **78**. The walls **78** can be provided, for example, on an insert that is inserted from below, i.e. from the separation plane **29**, into the cylinder **82**. For the production of the transfer passages **81** and **83** for two-stroke engines with different engine displacements only one transfer passage geometry is thus required. For producing all transfer passages, in case of manufacture by a casting process, the same core, in particular, the same sand core, can be used, respectively. The manufacture is thus simplified.

In the embodiment shown in FIG. **18**, the common channels **95** of the transfer passages **81** and **83** open with mouths **28"** into the crankcase; the flow cross-section is reduced by walls **79**. The walls **79** are arranged in slanted position relative to the separation plane **29** on the outwardly positioned side walls **90** positioned opposite the inwardly positioned side walls **89**. The side walls **90** delimit the inlet-near transfer passages **83**. The walls **78** and **79** may be inclined, as shown in FIGS. **17** and **18**, relative to the separation plane **29**. However, it can also be provided that the walls **78** of FIG. **17** are perpendicular to the separation plane **29** and extend up to the inwardly positioned side walls **89**.

In the embodiment of FIG. **19**, walls **80** are provided that reduce the flow cross-section of the mouths **26'''**. The walls **80** are arranged on the radially outwardly positioned outer walls **94** of the common channels **95** and can be arranged, like the walls **78** and **79**, at a slant relative to the separation plane **29**. Also, the walls **80** can extend perpendicularly to the separation plane **29** in upward direction until they intersect the outer walls **94**.

In the embodiment shown in FIG. **20**, walls **78** are provided on the inner walls **92** of the common channels **95** and reduce the flow cross-section of the mouths **28""**. Also, the walls **92** can extend at a slant relative to the separation plane **29**. It may also be provided to realize an adaptation of the flow cross-section of the transfer passages **81**, **83** by other measures.

FIGS. **21** and **22** show a two-stroke engine **100** that corresponds essentially to a two-stroke engine that encompasses the cylinder **82**. The two-stroke engine **100** has a cylinder **102** on which a circumferentially extending collar **103** is integrally formed that projects into the crankcase **104**. The collar **103** projects past the separation plane **29** into the crankcase **104**. The common channel **95** of the transfer passages **81** and **83** extends spirally within the cylinder **102** below the outlet **8**. In this connection, the common channel **95** intersects at a junction **88** an imaginary third dividing plane **32** of the cylinder **102** that corresponds to the dividing plane **32** of FIG. **2**. The junction **88** has a spacing p to the separation plane **29**.

In the cylinder **102** both common passage segments **95** of the transfer passages **81** and **83** that are combined in each case on one cylinder side are separated by a wall **65**. In the crankcase **104** the common channels **95** of both cylinder sides are joined. In this area the common channels **95** are separated by the collar **103** relative to the crankcase interior **42**. In the crankcase **104** a depression **105** is formed in which the common passage segment **106** of the common channels **95** is extending. By delimiting the segment of the transfer passages **81** and **83** that extends in the crankcase **104** by means of a collar **103** of the cylinder **102** and a depression **105** of the crankcase **104** a simple configuration is provided. FIG. **22** shows a section plane that is rotated relative to the center plane of the cylinder **102**. Here the junction of a channel **95** and the extension of the channel **95** along the wall **65** are shown.

FIG. **23** shows an embodiment of a cylinder **112** whose separation plane **119** is at the level of the axis of rotation **26** of the crankshaft **7**. The transfer passages **91** and **93** are embodied completely in the cylinder **112** and do not pass into the crankcase, not shown. As shown in FIG. **23**, inlet-near transfer passages **93** and outlet-near transfer passages **91** are provided that are joined before reaching a junction **88** into the second sector **35** of the cylinder **112** where the outlet **8** is provided. The junction **88** is arranged at a spacing q to the separation plane **119** so that the transfer passages **91** and **93** are extended into the area of the outlet **8** above the separation plane. Below the outlet **8** the common channels **95** of both cylinder halves are joined to a common passage segment **116**. The transfer passages **91** and **93** open at a common opening **117** into the crankcase interior **42**.

FIGS. **24** and **25** show a sand core **107** for producing the cylinder **112**. The sand core **107** molds all transfer passages **91** and **93** and is embodied in a one-piece configuration. As shown in FIGS. **24** and **25**, the sand core **107** has two molding segments **110** which mold the outlet-near transfer passages **91** as well as two molding segments **111** which mold the inlet-near transfer passages **93**. Both molding segments **110** are connected with each other in the area forming the transfer ports by a connecting segment **108**. A second connecting segment **109** is provided between the areas of the molding segments **111** which mold or form the transfer ports of the transfer passages **93**. The sand core **107** has two molding segments **113** which mold the common channels **95** of the transfer passages **91** and **93**. Both molding segments **113** are connected with each other by a molding segment **114** that molds or forms the common passage segment **116** of the common channels **95**. In order to enable a simple manufacture of the sand core **107**, the inner side walls **115** shown in FIG. **25** and the outer side walls **118** of the segments **111** of the sand core **107** extend parallel to each other. The side walls **115** and **118** are inclined by angle α relative to the longitudinal cylinder axis **24** of the finished cylinder which angle may amount to several degrees. The angle α ensures that the sand core **107** can be removed.

In order to enable removal of the sand core **107**, it is also provided that the side walls **120** of the segments **110** and **111** facing each other are slanted away from each other. In this connection, the side walls **120** extend away from each other in such a way that, for drawing the mold for producing the sand core **107**, no undercuts are formed in the side walls **120** in the direction of the longitudinal cylinder axis **24**. Also, the connecting segments **108** and **109** are so arranged that for removal of the sand core **107** one mold half can be drawn in the direction of the longitudinal cylinder axis **24** upwardly and the second mold half in the direction of the longitudinal cylinder axis **24** downwardly, without undercuts being formed. Advantageously, drafts (ramps) are formed on surfaces of the sand core **107** that extend roughly parallel to the longitudinal cylinder axis **24**.

FIGS. **26** to **32** illustrate the course of the transfer passages **91** and **93** in several sections of the cylinder **112**. FIG. **27** shows a section at the cylinder bottom **25**. The common passage segment **116** of the common channels **95** opens in this area with an opening **117** into the crankcase interior. As shown in FIG. **27**, the opening **117** is arranged in a second sector **35** in which also the outlet **8** (FIG. **32**) is arranged. As shown in FIGS. **27** and **28**, the outer wall **170** of the common passage segment **116** that extends relative to the longitudinal cylinder axis **24** radially outwardly is curved. The outer wall **170** is embodied as a segment of a circle whose center is located on the longitudinal cylinder axis **24**. As shown in FIG. **28**, the radially inwardly positioned inner wall **171** of the common passage segment **116** is also embodied as a segment of a circle that is concentric to the longitudinal cylinder axis **24**.

FIG. **29** shows a section of the cylinder **12** at a level where the common passage segment **116** is branching into the two common channels **95**. Both channels **95** are separated at this level by a thin wall segment from each other. The radially outwardly positioned outer walls **172** of the common channels **95** are embodied as circular segments concentric to the longitudinal cylinder axis **24**. The radially inwardly positioned inner walls **173** of the common channels **95** are circular segments concentric to the longitudinal cylinder axis **24**. The distance of the inner walls **173** to the cylinder bore is therefore constant about the entire width of the common channels **95**. In the section representation shown in FIG. **29**, the common channels **95** are arranged approximately completely in the second sector **35**.

FIG. **30** shows a section of the cylinder **112** at a level where the common channels **95** pass from the second sector **35** into the first sector **34** or the third sector **36**. Imaginary dividing planes **32** and **33** intersect the common channels **95** at this section plane. As shown in FIG. **30**, the radially outwardly positioned outer walls **172** and the radially inwardly positioned inner walls **173** also extend at the section plane of FIG. **30** on circles concentric to the longitudinal cylinder axis **24**. The distance of the inner walls **173** and the outer walls **172** relative to the cylinder bore is thus constant. Dead volumes between the common channels **95** and the cylinder bore can be avoided in this way. The transfer passages can extend closely around the cylinder bore.

FIG. **31** shows a section representation of the cylinder **112** where the common channels **95** are arranged completely in the first sector **34** or in the third sector **36**. At this section level the inner walls **173** and the outer walls **172** also extend on circles that are concentric to the longitudinal cylinder axis **24**.

FIG. **32** shows a section below the transfer ports of the transfer passages **91** and **93**. Between the section plane of FIG. **31** and the section plane of FIG. **32** the common channels **95** have branched into the transfer passages **91** and **93**. The transfer passages **91** have each an outer wall **174** and an inner wall **175**. The transfer passages **93** have each an inwardly positioned inner wall **177** and an outer wall **176** that is facing away from the cylinder bore. The inner walls **175** and the outer walls **174** of the outlet-near transfer passages **91** are embodied as circular segments of circles that are concentric to the longitudinal cylinder axis **24**. The inner walls **177** and the outer walls **176** of the inlet-near transfer passages **93** deviate slightly from the circular segment shape in order to be able to realize the desired inflow angle of the transfer ports.

As shown in FIGS. **27** to **32**, a compact configuration of the cylinder **112** results by the arrangement of the transfer passages in a spiral shape and concentric to the longitudinal cylinder axis **24**. Material accumulations that can negatively affect the casting quality when producing the cylinder **112** in a casting process are avoided. At the same time a uniform flow guiding action is realized that causes the two-stroke engine to have low exhaust gas values.

Another embodiment of a cylinder **122** is shown in FIGS. **33** to **35**. The cylinder **122** has also a separation plane **119** that extends at the level of the axis of rotation **26** of the crankshaft **7**. The cylinder **122** has two outlet-near transfer passages **121** and two inlet-near transfer passages **123** that are embodied completely within the cylinder **122**. The transfer passages **121** and **123** are joined to a common channel **124**. The common channels **124** intersect the imaginary dividing plane **32** at a junction **128** that has a spacing r to the separation plane **119**. Below the outlet **8** the two common channels **124** are joined in a common passage segment **125**. All four transfer passages **121** and **123** open at a common opening **126** into the crankcase interior **42**.

In the embodiment of a two-stroke engine **130** shown in FIG. **36**, two outlet-near transfer passages **131** that open with transfer ports **132** into the combustion chamber **3** and two inlet-near transfer passages **133** that open with transfer ports **134** into the combustion chamber **3** are provided. Two transfer passages **131** and **133** that are neighboring each other are joined in a cylinder **142** of the two-stroke engine **130** to form a common channel **138**. The common channels **138** of the oppositely arranged transfer passages **131** and **133** are joined below the outlet **8** in a common passage segment **96** which opens with an opening **97** into the crankcase interior **42**.

In this connection, the transfer passages **131** are shorter than the transfer passages **133**. The outlet-near transfer passages **131** have a length u that is smaller than the length v of the inlet-near transfer passages **133**. On account of the different lengths u, v of the transfer passages **131** and **133** turbulences may result in the area of the common channel **138**. These turbulences result from the difference in time that the scavenging air needs for traveling in the transfer passages **131** or **133** from the supply passage **16** toward the common channel **138**. To avoid this, it is provided that the transfer ports **132** and **134** have different control timing. The transfer port **132** has a control edge **135**; this control edge **135** is the edge of the transfer port **132** that is opened first with the downward stroke of the piston **5**. The transfer ports **134** have a corresponding control edge **136**. Measured parallel to the longitudinal cylinder axis **24**, the control edges **135** and **136** have a spacing l to each other.

The cylinder **142** has a combustion chamber cover **141** that delimits the cylinder **142** at the side facing away from the crankcase **4**. The piston **5** has a piston bottom **139** delimiting the combustion chamber **3**. The control edge **135** has a spacing w relative to the piston bottom **139** when the piston **5** is at bottom dead center (shown in FIG. **25**) and the spacing w is smaller than a spacing x of the control edge **136** to the piston bottom **139** in this position of the piston **5**. The transfer port **134** close to the inlet is thus opened first toward the combustion chamber **3**.

When opening the transfer ports **132**, **134** a pressure wave passes from the combustion chamber **3** into the transfer passages **131** and **133**. Since the transfer port **134** opens before the transfer port **132** opens toward the combustion chamber **3**, the pressure wave can already travel a certain distance in the inlet-near transfer passages **133** before the transfer passages **131** open toward the combustion chamber **3**. In this way, it can be achieved that the pressure waves in both transfer passages reach approximately at the same time the area of the common channel **138**. In this way, it is achieved that the scavenging air from the transfer passages **131** and **133** can stream approximately at the same time into the combustion chamber **3**, although different control timings are provided for the transfer passages. However, by means of different control timing of the transfer passages **131** and **133** also a non-uniform flow can be realized, if so desired. The two-stroke engine **130** has a center plane **137** relative to which the cylinder **142** is embodied symmetrically.

In FIG. **37** an embodiment of a two-stroke engine **140** is shown whose design corresponds essentially to that of two-stroke engine **70** shown in FIG. **6**. The two-stroke engine **140** has transfer passages **71** and **73** which extend about a part of their length in a cylinder **72**. In the cylinder **72** a piston **145** is supported reciprocatingly and delimits the combustion chamber **3** in the cylinder **72**. The piston **145** has a piston recess **143** that is closed toward the crankcase interior **42** and is arranged in the area of the transfer port **14** of the inlet-near transfer passage **73**. In the area of the top dead center of the piston **145**, scavenging air is supplied through the piston recess **143** from the supply passage **16** into the inlet-near transfer passage **73**. The outlet-near transfer passage **71** is not connected in any position of the piston **145** with the piston recess **143**. Thus, scavenging air supplied into the transfer port **14** flows in the direction of arrow **146** shown in FIG. **37** from the transfer passage **73** into the transfer passage **71**.

In the piston **145** a piston port **144** is provided in the area of the outlet-near transfer port **12**; in the area of top dead center of the piston **145** the piston port **144** connects the transfer port **71** with the crankcase interior **42**. In this way, the transfer passage **71** can be scavenged completely with scavenging air from the transfer passage **73**. Through the transfer passage **73** scavenging air is also supplied into the common channel **51**. In operation of the two-stroke engine **140** scavenging air from the supply passage **16** is supplied through the transfer port **14** into the transfer passage **73** and in the direction of the arrow **146** through the common channel **51** into the transfer passage **71**. The residual mixture from the last cycle that may still exist in the transfer passage **71** is forced through the transfer port **12** and the piston port **144** into the crankcase interior **42** so that the transfer passage **71** is scavenged completely.

In FIG. **38** a two-stroke engine **150** is shown which has a cylinder **152** in which two transfer passages **153** are formed on opposite sides of a center plane **157**. The transfer passages **153** each open with a transfer port **154** into the combustion chamber **3** embodied in the cylinder **152**. The transfer passages **153** extend into the area of the mixture inlet **9** and surround in a spiral shape the cylinder **152**. In the area of the cylinder bottom **25** the transfer passages **153** pass into the crankcase **4**. In this connection, the transfer passages **153** are joined in the separation plane **29** between cylinder **152** and crankcase **4**. In the crankcase **4** both transfer passages **153** extend in a common passage segment **156** that opens with an opening **155** into the crankcase interior **42**.

In the embodiment of a two-stroke engine **160** shown in FIG. **39** two transfer passages **163** are embodied in a cylinder **162** and are arranged on opposite sides of a center plane **157**; they each open with a transfer port **164** into the combustion chamber **3**. The transfer passages **163** are joined below the outlet **8** at the separation plane **29**. In the crankcase **4** both transfer passages **163** extend in a common passage segment **166** that opens with opening **165** into the crankcase interior **42**. The two-stroke engines **150** and **160** illustrated in FIGS. **38** and **39** correspond otherwise to the other embodiments. The two-stroke engines **150** and **160** differ from the two-stroke engine **1** of FIG. **1** in that only one transfer passage is arranged on one side of the cylinder, respectively, and is guided below the outlet or the inlet.

FIG. **40** shows a piston **185** that can be utilized in a two-stroke engine working with scavenging air, for example, in the illustrated two-stroke engines **1**, **70**, **100**, **130**, **150** or **160**. In this connection, the two-stroke engine may have on each side of the cylinder a transfer passage or on each side of the cylinder two transfer passages, i.e., a total of four transfer passages.

The piston **185** has two symmetrically arranged piston recesses **183**, of which in FIG. **40** one is visible. Between the piston recess **183** and the piston bottom **187** a cutout **190** is arranged for weight reduction. As shown in FIG. **40**, the piston recess **183** has an upper edge **186** that is facing the piston bottom **187** and that does not extend straight but in circumferential direction of the piston has a section that is coiled or spirally shaped. In FIG. **40** transfer ports **12** and **14** are shown schematically as well as the opening of the supply passage **16**. As shown in FIG. **40**, the upper edge **186** in the area of the transfer port **12** close to the outlet has a spacing **188** to the piston bottom **187** and in the area of the transfer port **14** close to the inlet has a spacing **189** to the piston bottom **187**. In this connection, the spacings **188**, **189** are measured parallel to the longitudinal cylinder axis.

In the area of the outlet-near transfer port **12** the upper edge **186** extends in a side view of the piston **185**, at a slant to the longitudinal cylinder axis. In the area of the inlet-near transfer port **14** only a short segment of the upper edge **186** is positioned at a slant. Essentially, the upper edge **186** extends in the area of the inlet-near transfer port **14** perpendicularly to the longitudinal cylinder axis **24** that in FIG. **40** is shown schematically. Since the distance **189** is smaller than the distance **188**, the inlet-near transfer port **14** is connected first to the piston recess **183** and the supply passage **16**.

In the position of the transfer ports **12** and **14** shown in FIG. **40**, the outlet-near transfer port **12** is still closed relative to the piston recess **183**. Only upon further upward stroke of the piston **185** the outlet-near transfer port **12** is also connected with the piston recess **183**. The design of the piston recess **183** shown in FIG. **40** is in particular advantageous when the transfer passage that opens at the inlet-near transfer port **14** is longer than the transfer passage that opens at the outlet-near transfer port **12**, i.e., in particular when all transfer passages are extending below the outlet of the two-stroke engine. By means of the inclined course of the upper edge **186**, a steady instead of a sudden opening of the transfer port **12** into the piston recess **183** is provided.

The FIGS. **41** and **42** show an embodiment of a piston **195** which has two mirror-symmetrically embodied piston recesses **193**. The piston recesses **193** have an upper edge **196** facing the piston bottom **197**. The upper edge **196** extends essentially perpendicularly to the longitudinal cylinder axis **24**. However, the piston recesses **193** have neighboring to the inlet-near transfer port **14** (FIG. **42**) a segment **201** in which the upper edge **196** is arranged so as to be displaced in the direction of the piston bottom **197**. The distance **199** of the upper edge **196** in the area of the segment **201** is significantly smaller than the distance **198** of the upper edge **196** in the area of the outlet-near transfer ports **12**. The segment **201** extends in circumferential direction advantageously about a portion of the transfer port **14** and not about the entire transfer port **14**. Through the segment **201** the transfer port **14** is connected already with the supply passage **16** in the position of the piston **195** schematically shown in FIG. **42** while the transfer port **12** is still sealed relative to the piston recess **193**. Between the piston recess **193** and the piston bottom **197** a cutout **200** is provided for weight reduction. The design of a piston recess **193** shown in FIGS. **41** and **42** is in particular advantageous in two-stroke engines where the transfer passages that open at the transfer ports **14** are longer than the transfer passages that open in the transfer ports **12**, for example, in case of transfer passages extending below the outlet.

The shown shape of the transfer passages is advantageous for two-stroke engines which work with scavenging air as well as for two-stroke engines without scavenging air. For two-stroke engines with scavenging air as well as for two-stroke engines without scavenging air low exhaust gas values are obtained. The good flow properties and the low exhaust gas values also result from the arrangement of the transfer passages concentric to the longitudinal cylinder axis **24**, as shown in particular in FIG. **27** to **32**. This embodiment of the inner walls and the outer walls of the transfer passages as circular segments concentric to the longitudinal cylinder axis **24** is advantageous for all shown cylinders.

The specification incorporates by reference the entire disclosure of German priority document 10 2009 059 143.5 having a filing date of Dec. 19, 2009.

While specific embodiments of the invention have been shown and described in detail to illustrate the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A two-stroke engine comprising:

a cylinder with a combustion chamber disposed therein;

a piston reciprocatingly supported in the cylinder and delimiting the combustion chamber;

a crankshaft rotatably supported in a crankcase and driven in rotation by the piston;

at least two transfer passages having an opening that opens into an interior of the crankcase, the at least two transfer passages connecting the crankcase in at least one position of the piston with the combustion chamber, wherein the transfer passages each open by a piston-controlled transfer port provided in the cylinder into the combustion chamber;

wherein the at least two transfer passages each have a passage length beginning at the transfer port and ending at the opening;

an inlet that opens into the crankcase;

an outlet provided at the combustion chamber;

wherein the two-stroke engine is dividable into four sectors: a first sector, a second sector, a third sector, and a fourth sector that extend parallel to a longitudinal cylinder axis, respectively;

wherein the transfer port of a first one of the transfer passages is arranged in the first sector, wherein the outlet is arranged in the second sector adjoining the first sector, wherein the transfer port of a second one of the transfer passages is provided in the third sector adjoining the second sector, and wherein the inlet into the crankcase is arranged in the fourth sector that is located between the first sector and the third sector;

wherein, within the cylinder, the first and second transfer passages each have a segment of the passage length, said segment of the passage length arranged at a spacing to a separation plane between the cylinder and the crankcase, wherein said segments of the passage length pass together into one of the second and fourth sectors adjoining the first and third sectors;

wherein the first and second transfer passages have a common passage segment in which the first and second transfer passages extend together, wherein the common passage segment is a segment of the passage length of the first and second transfer passages located at an end of the passage length facing the crankcase; and wherein the common passage segment ends at the opening of the first and second transfer passages and opens with the opening of the first and second transfer passages into the crankcase, wherein the opening of the first and second transfer passages is positioned in the second sector below the outlet or is positioned in the fourth sector below the inlet.

2. The two-stroke engine according to claim **1**, wherein the first and second transfer passages are joined at the separation plane between the cylinder and the crankcase.

3. The two-stroke engine according to claim **1**, wherein the first and second transfer passage are joined within the cylinder.

4. The two-stroke engine according to claim **1**, wherein the first and second transfer passages have radially outwardly positioned outer walls and radially inwardly positioned inner walls, wherein the inner and outer walls are positioned at least over a section of the length of the first and second transfer passages as circular segments that extend approximately concentric to the longitudinal cylinder axis.

5. The two-stroke engine according to claim **1**, wherein the crankcase is comprised of two half shells joined at a joining plane extending parallel to the longitudinal cylinder axis, wherein the first and second transfer passages extend in the crankcase within the joining plane.

6. The two-stroke engine according to claim **1**, wherein the crankcase has a depression and wherein the cylinder has a collar that extends past the separation plane between the crankcase and the cylinder into the crankcase, wherein the collar and the depression together form the first and second transfer passages.

7. The two-stroke engine according to claim **1**, wherein the cylinder has four of the transfer ports, wherein two of the four transfer ports are arranged in the first sector and two of the four transfer ports are arranged in the third sector.

8. The two-stroke engine according to claim **7**, wherein two of the four transfer passages are joined with a segment of their respective passage length that is located in the second sector, respectively, and two of the four transfer passages are joined with a segment of their respective passage length that is located in the fourth sector, respectively.

9. The two-stroke engine according to claim **7**, wherein the four transport passages connected to the four transfer ports are all joined in a segment of their respective passage length within one of the four sectors.

10. The two-stroke engine according to claim **7**, wherein:

the transfer port of a first one of the transfer passages and the transfer port of a second one of the transfer passages open together in the first sector or in the third sector into the combustion chamber, wherein the transfer port of the first transfer passage is arranged near the inlet and the transfer port of the second transfer passage is arranged near the outlet;

wherein the passage length of the first transfer passage with the transfer port positioned near the inlet is longer than the passage length of the second transfer passage with the transfer port positioned near the outlet;

wherein the piston has a piston bottom delimiting the combustion chamber;

wherein the transfer port of the first transfer passage has a first control edge where upon downward stroke of the piston the transfer port of the first passage is opened first and wherein the transfer port of the second transfer passage has a second control edge where upon downward stroke of the piston the transfer port of the second transfer passage opens first;

wherein the first control edge has a first spacing to the piston bottom at bottom dead center of the piston and the second control edge has a second spacing to the piston bottom at bottom dead center of the piston, wherein second spacing is smaller than the first spacing;

wherein the transfer port of the first transfer passage that is longer opens upon downward stroke of the piston before the transfer port of the second transfer passage that is shorter.

11. The two-stroke engine according to claim **7**, wherein two of the transfer passages connected to the two transfer ports arranged together in the first sector or the third sector are joined in a common channel in a segment of the respective passage length, wherein joining of the two transfer passages to form the common channel begins at a spacing from the separation plane between the cylinder and the crankcase, and wherein the two transfer passages are joined in the first sector or the third sector where the two transfer ports to which the two transfer passages are connected are located.

12. The two-stroke engine according to claim **7**, comprising a supply passage for scavenging air that opens at the cylinder, wherein the piston has a piston recess that connects the supply passage to one of the transfer ports near the inlet, wherein one of the transfer ports near the outlet is connected through the piston to the crankcase interior.

13. The two-stroke engine according to claim **7**, comprising a supply passage for scavenging air that opens at the cylinder, wherein the piston has a piston recess that connects the supply passage with the transfer ports, wherein a first one of the transfer ports in at least one position of the piston is completely sealed and a second one of the transfer ports neighboring the first one is already connected through the piston recess with the supply passage.

14. The two-stroke engine according to claim **7**, comprising a supply passage for scavenging air that opens at the cylinder, wherein the piston has a piston recess that connects the supply passage with the transfer ports, wherein the piston recess has an upper edge having a spacing to a piston bottom of the piston, wherein the spacing changes in a circumferential direction of the piston.

15. The two-stroke engine according to claim **1**, wherein at least one of the transfer passages extends within the cylinder such that a mouth of the at least one transfer passage has a wide side and a narrow side measured perpendicularly to the wide side, wherein a length of the wide side decreases in cross-sections perpendicular to a flow direction to the transfer port of the at least one transfer passage, wherein a length of the narrow side increases in cross-sections perpendicular to the flow direction to the transfer port of the at least one transfer passage, wherein in a cross-section, taken perpendicular to the flow direction adjacent to the transfer port, the length of the wide side is smaller than the length of the narrow side, and wherein a product of the length of the wide side and the length of the narrow side for each one of the cross-sections of the transfer passage taken perpendicular to the flow direction is essentially the same.

16. A two-stroke engine comprising:

a cylinder with a combustion chamber disposed therein;

a piston reciprocatingly supported in the cylinder and delimiting the combustion chamber;

a crankshaft rotatably supported in a crankcase and driven in rotation by the piston;

at least four transfer passages connecting the crankcase in at least one position of the piston with the combustion chamber, wherein the transfer passages each open by a piston-controlled transfer port provided in the cylinder into the combustion chamber;

an inlet that opens into the crankcase;

an outlet provided at the combustion chamber;

wherein the two-stroke engine is dividable into four sectors: a first sector, a second sector, a third sector, and a fourth sector that extend parallel to a longitudinal cylinder axis, respectively;

wherein the transfer port of a first one of the transfer passage and the transfer port of a second one of the transfer passages are arranged in the first sector, wherein the outlet is arranged in the second sector adjoining the first sector, wherein the transfer port of a third one of the transfer passages and the transfer port of a fourth one of the transfer passages are provided in the third sector adjoining the second sector, and wherein the inlet into the crankcase is arranged in the fourth sector that is located between the first sector and the third sector;

wherein the transfer passages extend within the cylinder in a spiral shape about the combustion chamber;

wherein, within the cylinder, the first and second transfer passages, at a spacing to a separation plane between the cylinder and the crankcase pass together into the second sector;

wherein the first, second, third, and fourth transfer passages open with a common opening into the crankcase in the second sector.

17. The two-stroke engine according to claim **16**, wherein the first, second, third, and fourth transfer passages have a passage length beginning at the transfer port and ending at an opening into the crankcase, respectively, wherein the first, second, third, and fourth transfer passages have a common passage segment in which the first, second, third and fourth transfer passages extend together, wherein the common passage segment is a segment of the respective passage length at an end of the first, second, third, and fourth transfer passages that is facing the crankcase, and wherein the common passage section opens with the openings of the first, second, third and fourth transfer passages into the crankcase.

18. The two-stroke engine according to claim **16**, wherein the first, second, third, and fourth transfer passages are joined within the common passage segment.

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